152

AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 48 No. 8 AUGUST 1958 PRICE: 3s. 6d.

MIDCYL RESEARCH also helps smooth out problems

like the potter gently smoothing out his clay Midcyl research helps smooth the way of the Auto Engineer with such of his problems as are associated with Cylinder Blocks, Cylinder Heads, Camshafts and Brake Drums

MIDCYL

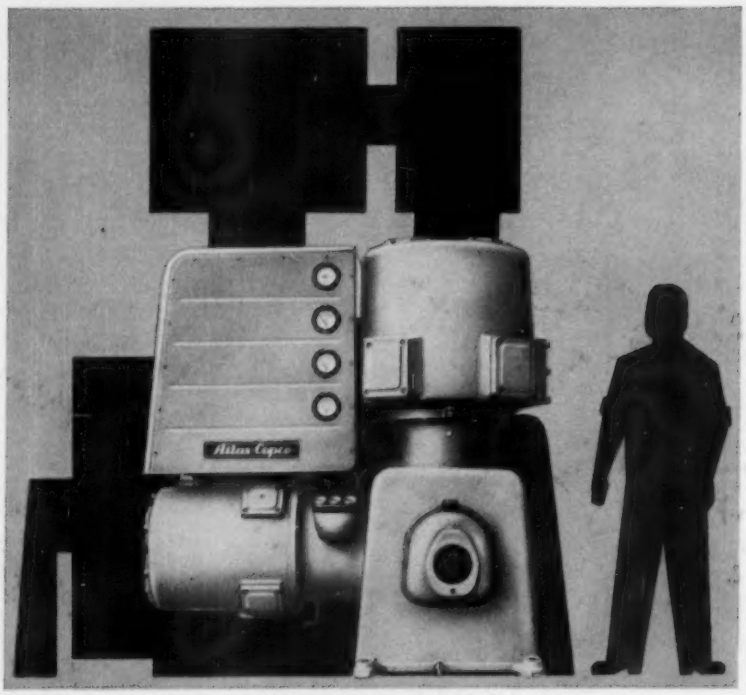
THE MIDLAND MOTOR CYLINDER CO. LTD., SMETHWICK, STAFFS

H-W.80

New Compressor Design

GIVES OUTSTANDING SPACE SAVING WITH REDUCED RUNNING COSTS

The Atlas Copco ER6 is a new stationary compressor which uses fundamental improvements in design to achieve remarkable results in performance and efficiency. The illustration shows the size of the ER6 compared with a conventional compressor of similar output: yet this extraordinary saving in space is achieved with *added* efficiency and economy, and with the same reliability of operation, which has characterised Atlas Copco compressors for 50 years.



PRINCIPAL DATA

Maximum pressure in psi	Speed in rpm	Low-pressure piston displacement in cfm	Free air delivered at 100 psi in cfm	Cooling water required at 60°F approx in galls/hour	Weight in pounds
125	485	1,303	1,075	440	6,600

Economy of operation

The specific power consumption for the ER6 is 10-15% lower than for most machines of this size on the market. At 4,000 hours running time per year this means an *annual power saving of up to* £360.

In addition the cooling water consumption of the ER6 is very low because of the special design of the intercooler, amounting to only 440 gallons per hour at 60°F. This is less than half the quantity needed for the majority of other similar air compressors.

Economy of installation

The ER6 requires an exceptionally small amount of floor space for its capacity. This reduces the cost of foundation and erection, especially with the use of a flange-mounted motor.

Erection and alignment can be simplified by using a base frame which can be delivered as extra equipment. The balance is so good that the ER6 can be mounted on a skid frame, which does not require a concrete foundation. Skid frame mounting is especially advantageous for contractors and makes it possible for the compressors to be moved easily and at low cost from one site to another.

The ER6 is equipped with an oil pressure control device and cooling water gauges together with a full set of instruments for visual control.

A complete range of compressed air equipment

Atlas Copco manufactures portable and stationary compressors, rock-drilling equipment, loaders, pneumatic tools and paint-spraying equipment. Sold and serviced by companies or agents in ninety countries throughout the world.

Atlas Copco PUTS COMPRESSED AIR TO WORK FOR THE WORLD

Contact your local company or agent or write to Atlas Copco AB, Stockholm 1, Sweden

C.30 G.B.

ARCHDALE

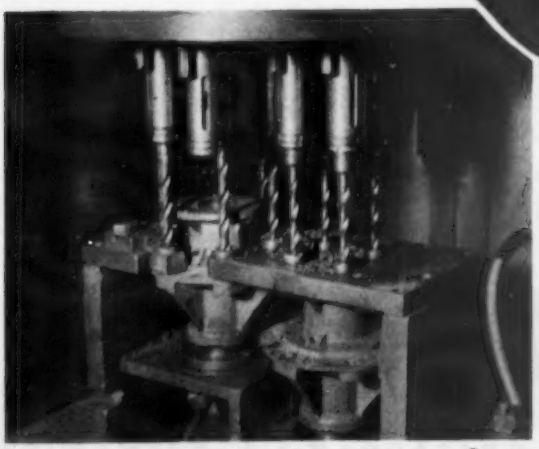
Multiples..

SPEED PRODUCTION AT INTERNATIONAL HARVESTER

With hydraulic feed and sliding head, these are the machines to slash costs where multi-drilling on batch production is involved. At International Harvester Co. (Gt. Britain) Ltd., Doncaster, for instance, 6, $\frac{33}{64}$" and 4, $\frac{13}{32}$" diameter holes are drilled in hubs for baling machines at the rate of 55 hubs per hour.

These machines can be supplied with circular or rectangular heads, with up to twelve adjustable spindles with a capacity, according to size of machine, for drilling holes from $\frac{3}{8}$" to $1\frac{1}{4}$" diameter. Machines with fewer spindles naturally have a greater capacity.

Ask for complete details and production data on your own work.



JAMES ARCHDALE & CO. LTD.
LEDSAM ST. BIRMINGHAM, 16
Telephone No. EDGbaston 2276
A Member of the Staveley Coal & Iron Co., Ltd., Group
Sole Agents: ALFRED HERBERT LTD. COVENTRY
Telephone No. 89221

FROM EVERY ANGLE

The BROOK 'C' type motor represents the finest value in the world. This new design embodies the results of fifty years progress and research. It complies with British Standard 2960:1958.

Smaller size—lighter weight—better ventilation—new terminal board and cover—high output—moderate temperature rise—inexpensive.

BROOK MOTORS Ltd — HUDDERSFIELD • ENGLAND

CHICAGO • U.S.A. — BROOK MOTOR CORPORATION

58/2

KIRKSTALL AXLES

FOR

BUSES

TRUCKS

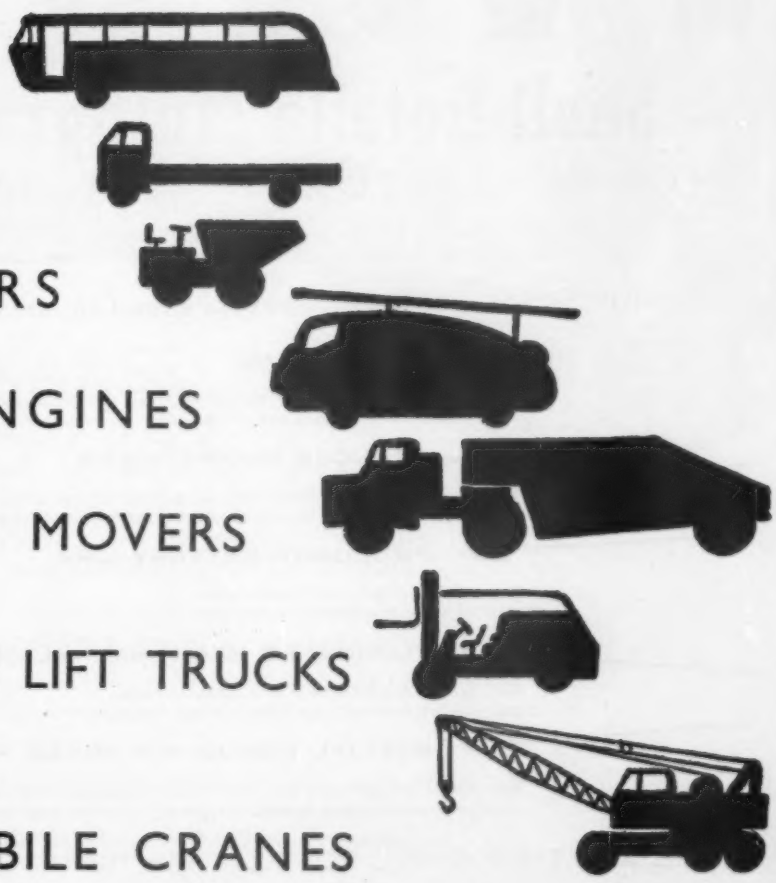
DUMPERS

FIRE ENGINES

EARTH MOVERS

FORK LIFT TRUCKS

MOBILE CRANES



KIRKSTALL FORGE ENGINEERING LIMITED

LEEDS, 5

Telephone: Horsforth 2821

NEW!

Shell Rotella Multigrade Oils

FOR INCREASED OPERATIONAL EFFICIENCY

From the same range as the world-famous Shell Rotella Oils now comes
Shell Rotella Multigrade, an entirely new type of oil for commercial vehicles.

Shell Rotella Multigrade gives these added advantages over other oils

FUEL SAVING

Extensive bench and field tests showed that Shell Rotella Multigrade gives a worthwhile saving on fuel. *This economy was most marked on stop/start work and short haul transport.*

REDUCES ENGINE WEAR

Shell Rotella Multigrade flows freely the moment the engine starts and gives immediate engine protection. Shell Rotella Multigrade combats corrosion and abrasive wear.

PROLONGS BATTERY LIFE

Because Shell Rotella Multigrade makes starting easier it saves wear on batteries.

ELIMINATES SEASONAL OIL CHANGES

Shell Rotella Multigrade has an extended viscosity range and gives perfect lubrication summer and winter.

SPECIAL BONUS FOR MIXED FLEET OPERATORS

Shell Rotella Multigrade is ideal for both petrol and diesel engines. This means mixed fleet operators need only buy one oil for all their vehicles.

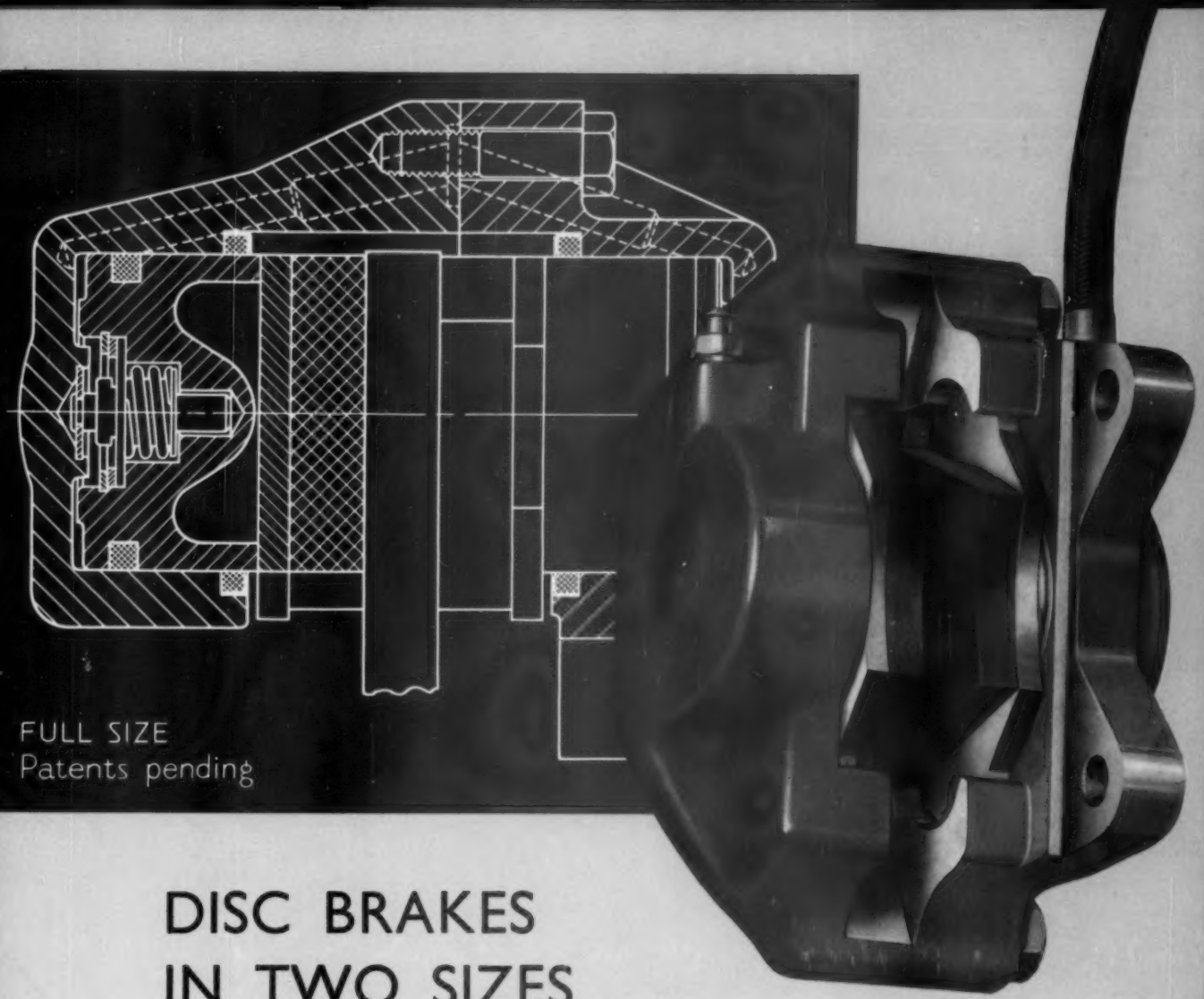
THERE ARE TWO SHELL ROTELLA MULTIGRADE OILS

Shell Rotella T oil Multigrade 10W/30—for engines that need "Supplement 1" lubricating oils.

Shell Rotella oil Multigrade 10W/30—for engines that do not need such a high additive level oil.

SHELL **Shell Rotella Multigrade Oils**

LEADERSHIP IN LUBRICATION



FULL SIZE
Patents pending

DISC BRAKES IN TWO SIZES

The print shows the heavy type for discs 10 to 12-in. diameter, with friction pads ¼-in. thick and 7¼ sq. in. area.

The medium type, shown on the right, is for discs of 9½ to 11-in. diameter, the friction material is ⅜-in. thick, 5½ sq. in.

These two types cover practically every requirement, with ample sized friction pads that give normal mileage without replacement.

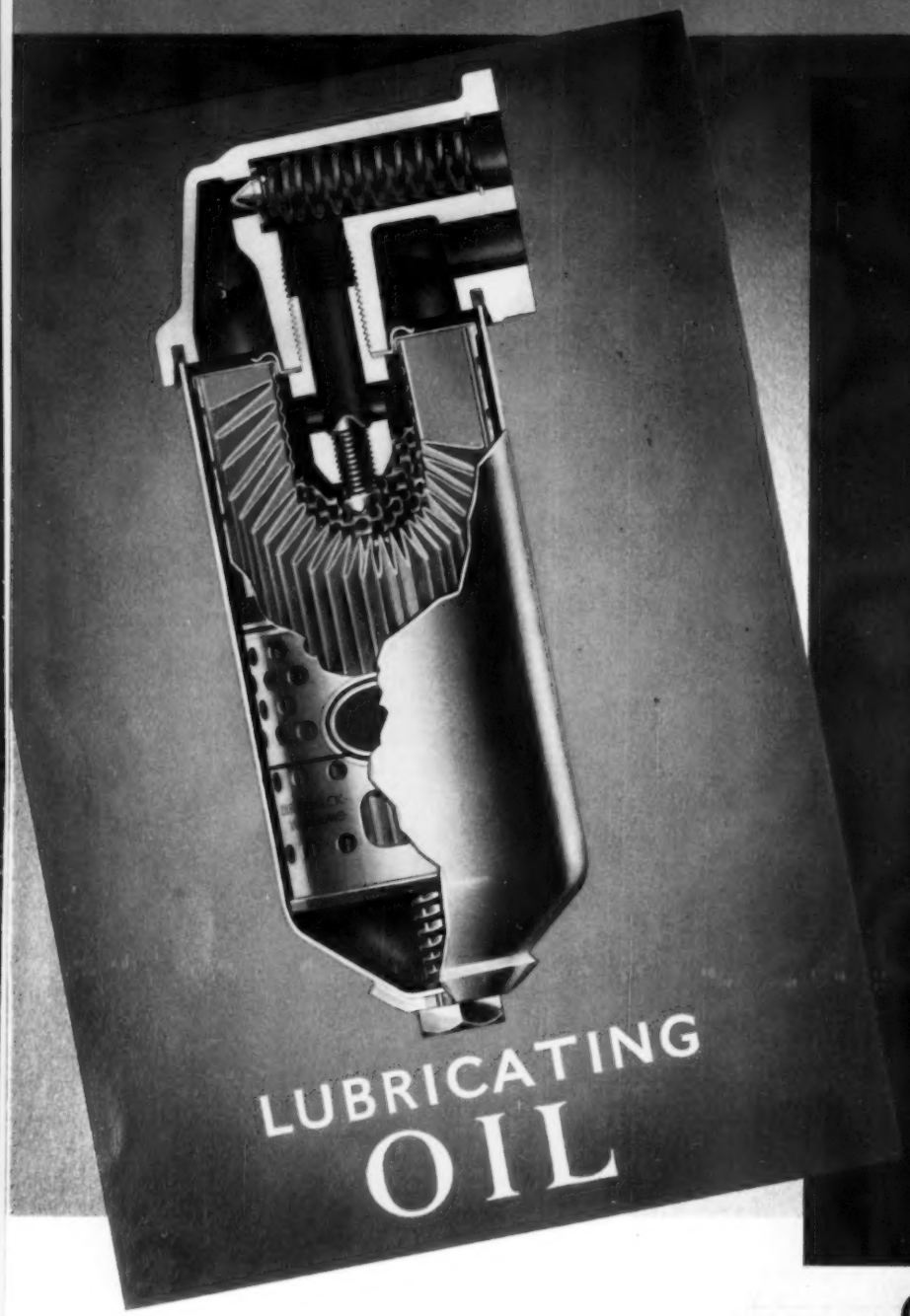
The automatic adjusters and the many other excellent features make this an outstanding brake, from the firm who are the pioneers of safe hydraulic braking.

LOCKHEED REGD. TRADE MARK

hydraulic disc brakes

AUTOMOTIVE PRODUCTS COMPANY LTD., LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

ORIGINATORS OF THE



LUBRICATING
OIL

FU

Covering the

Purolator filters are in use on commercial vehicles, agricultural tractors, passenger cars, industrial engines and air compressors.

Purolator 'Micronic' filters for lubricating oil, fuel and air are proving successful in every sphere.

AUTOMOTIVE PRODUCTS COMPANY LIMITED,

'MICRONIC' PUR

PAPER FILTER ELEMENT

EL

AIR

whole field

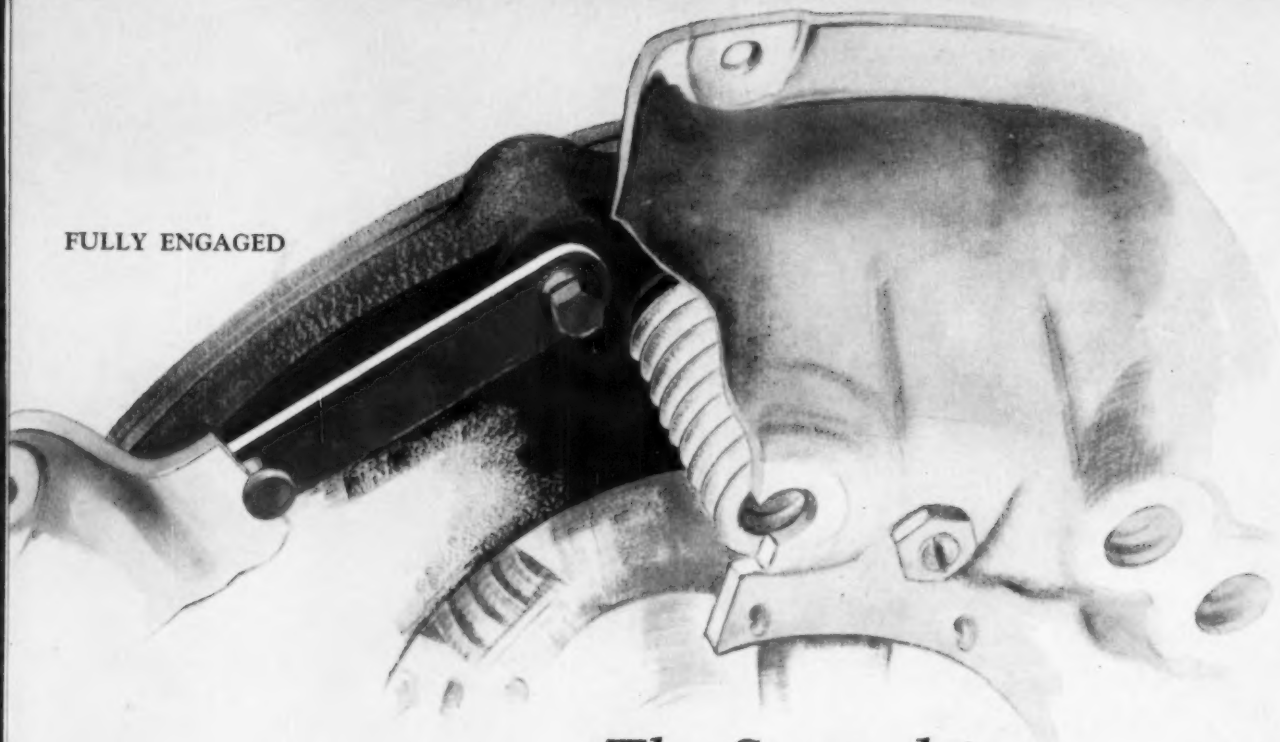
Purolator, first in the field with plastic-impregnated paper filters for fuel and oil, now lead the way with positive air filtration.

'Micronic' air filters are available in a wide range of sizes for throughputs of up to 500 c.f.m.

LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

Regd. Trade Marks: PUROLATOR : 'MICRONIC'

LATOR FILTERS



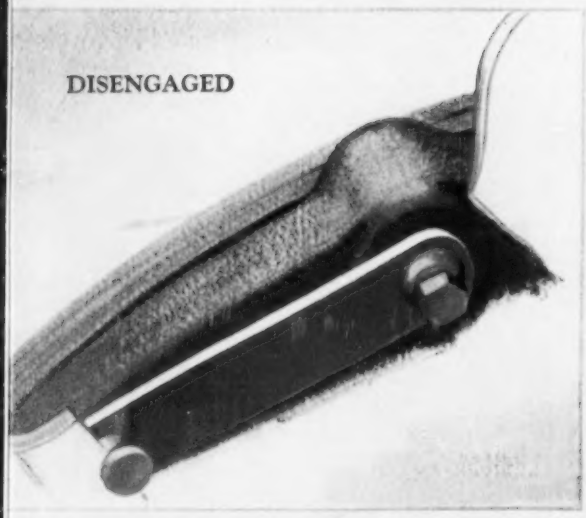
The Strap drive:

Elimination of sliding friction

The pressure plate in a Borg & Beck strap-drive clutch is constrained in every desired direction by the straps, without any friction at all.

The straps maintain concentricity, and by suitable proportioning their deflection permits travel from the disengaged position right through to the limit-of-wear position.

As a result, friction and mechanical wear are eliminated, and a smoother engagement is obtained.

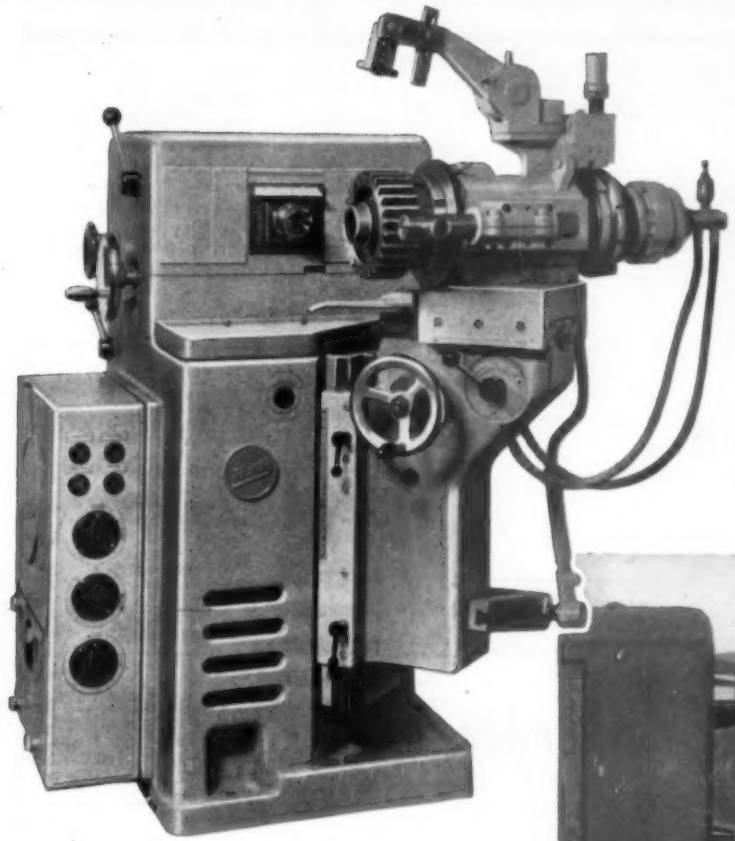


BORG & BECK COMPANY LTD.,
LEAMINGTON SPA, WARWICKSHIRE

BORG & BECK

REGISTERED TRADE MARK

Hurth AUTOMATIC



GEAR TOOTH ROUNDING & DE-BURRING MACHINES

●

TWO-SPINDLE HEAD AVAILABLE FOR VOLUME PRODUCTION

Fast approach of bell-type cutter, self indexing after reaching pre-set depth and automatic stopping on completion of cycle, make the HURTH Model ZK4 an ideal machine for batch work on spur and helical gears, starter rings, clutches, etc. Maximum work-piece dia.: 12". Range of teeth rounded : chamfered or de-burred 25-6 D.P., 7-110 teeth per gear. Speeds up to 120 teeth per minute.

LET US DEMONSTRATE TO YOU.

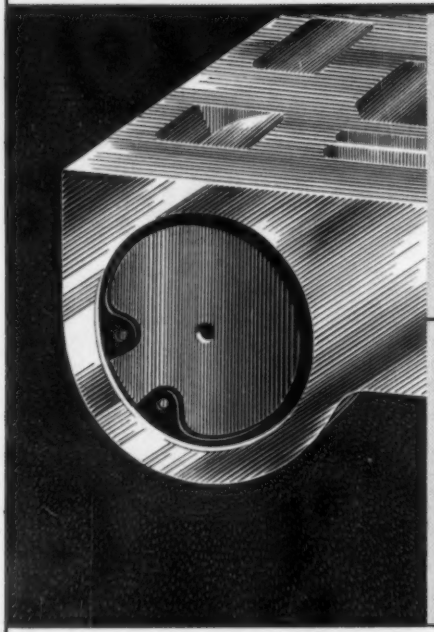
VAUGHAN ASSOCIATES LIMITED

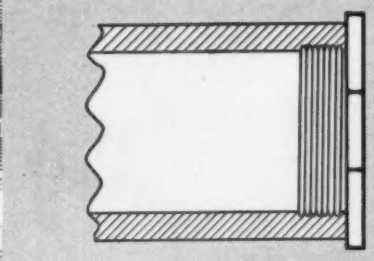
4, QUEEN STREET, CURZON STREET, LONDON, W.1
Telephone : GROSVENOR 8362-5

Midland Office: WILFORD CRESCENT, NOTTINGHAM
Telephone : NOTTINGHAM 88008.

NRP

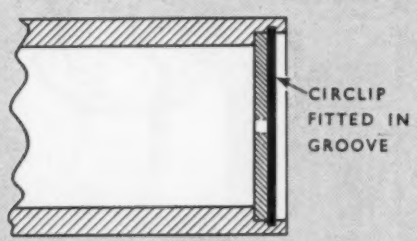
The logical advance in Retaining





OLD WAY

This fluid seal involved internal threading of the tube, which was sealed with an expensive cap-nut. The assembly was laborious and spanners were needed.



THE SALTER WAY

The tube is recessed and then simply grooved with the SALTER Grooving Tool. A Circlip is snapped into position and secures the fluid retaining plate with positive, vibration-free locking. When necessary the Circlip can be removed quickly and easily.

save material–reduce assembly time – cut costs

When it's a question of assembling components in any engineering field, Salter Retainers are the answer. They replace nuts and bolts, screws, cotter pins, and eliminate expensive threading and machining operations. A large standard range is at your immediate disposal, and we should welcome the opportunity to assist in developing special retainers to solve your problems.

Send for the Salter Retainer catalogue — no designer is complete without it.

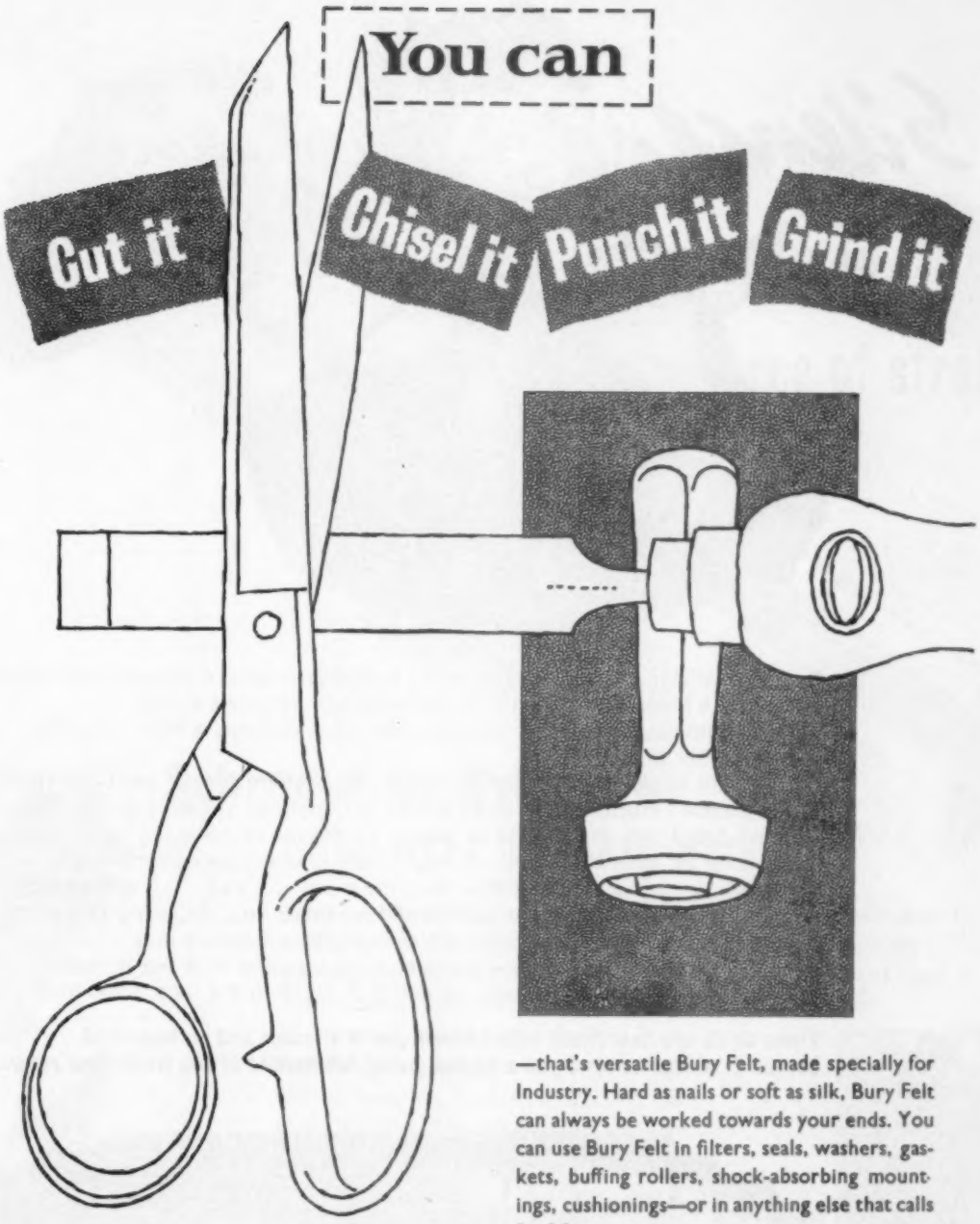
NEATER – MORE POSITIVE – PERMANENT RETAINING

SALTER "TRUARC"

Circlips · Fasteners · Retainers · Fixes

Geo. Salter & Co. Ltd., West Bromwich · Spring Specialists since 1760

M-W.448



—that's versatile Bury Felt, made specially for Industry. Hard as nails or soft as silk, Bury Felt can always be worked towards your ends. You can use Bury Felt in filters, seals, washers, gaskets, buffing rollers, shock-absorbing mountings, cushionings—or in anything else that calls for felt.

Versatile stuff— **BURY FELT**

Send your enquiries to

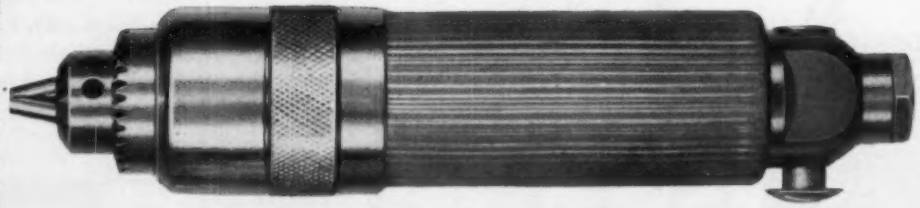
BURY FELT MANUFACTURING COMPANY LIMITED, P.O. BOX 14, HUDCAR MILLS, BURY, LANCASHIRE · Phone: BURY 2262 (6 lines)

London Offices: 3 Snow Hill, E.C.1 · Phone: Central 4448

Silence IS GOLDEN

Never satisfied! Always improving! A steady progress towards perfection—burbled the Managing Director in his most self-satisfied voice.
Take Pneumatic Drills. Efficient, you say—but perhaps a trifle noisy for the assembly line.
Sir, you are living in the past. This Little Horse here ("this 'ere Little Horse, if you please" muttered the Little Horse in question) operates a drill. Note that we have fitted him with a kind of gag or muffler, thus reducing the operating noise level by more than 50%. The principle is really very simple—as I will now demonstrate. I place this muffler over my mouth .... so .... I will now ask any member of the audience to wrap the ends—thank you, sir,—round behind my ears .... and N'mm M'mm Er'rm Ah'rmm Hurh'mm mm-m-mm ...!
(The audience agreed that the noise level had indeed dropped by well over 50% and the Managing Director was carried out, black in the face, amid loud cheers).

These drills are now fitted with a chuck guard silencer and an improved plastic grip. Let us send you a leaflet giving full details of the whole new range.



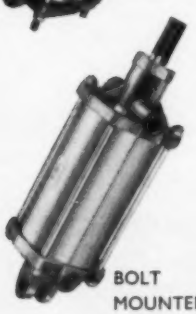
THE NEW **DESOUTTER SILENT** DRILLS

Manufactured by Desoutter Bros. Ltd., London.

DESOUTTER BROS. LIMITED, THE HYDE, HENDON, LONDON, N.W.9. TELEPHONE: COLINDALE 6346. TELEGRAMS: DESPNUCO, HYDE, LONDON.
RC 2818

With controlled speed and force of stroke

FLUSH MOUNTED TYPE



BOLT MOUNTED TYPE

Schrader Air Cylinders

make light of heavy work

Schrader Air Cylinders can be used in many ways to eliminate costly and bulky mechanical movements and to reduce the fatigue and monotony of manual movement. They can be operator controlled or automatically synchronized with other machine operations.
Piston movement can be regulated both for speed, force of stroke, and time of each cycle. Wherever you have operations involving lifting, lowering, pushing or pulling, consider the Schrader range of Air Cylinders. The chances are they can take over the heavy tasks and help you expand production.

Schrader
AIR CYLINDERS

SEND FOR DETAILS

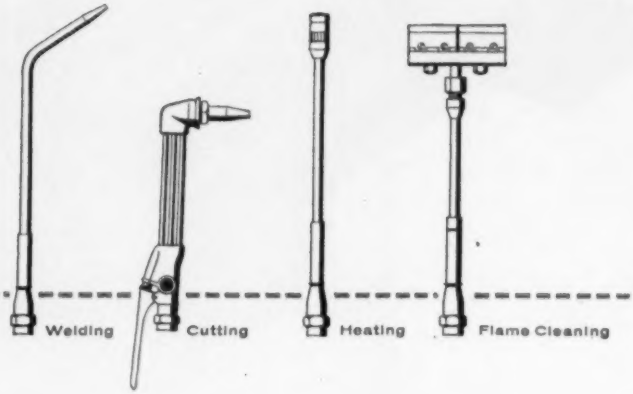
To: **A. SCHRADER'S SON**, Air Control Products Dept. AE,
829 TYBURN ROAD, ERDINGTON, BIRMINGHAM, 24

Please send details of Schrader Air Cylinders

NAME .....

ADDRESS .....

FROM BRITISH OXYGEN — FOR BRITISH INDUSTRY



Sensational Saffire 4 blowpipes in 1!

Common Shank to which any of these blowpipes can be fitted.

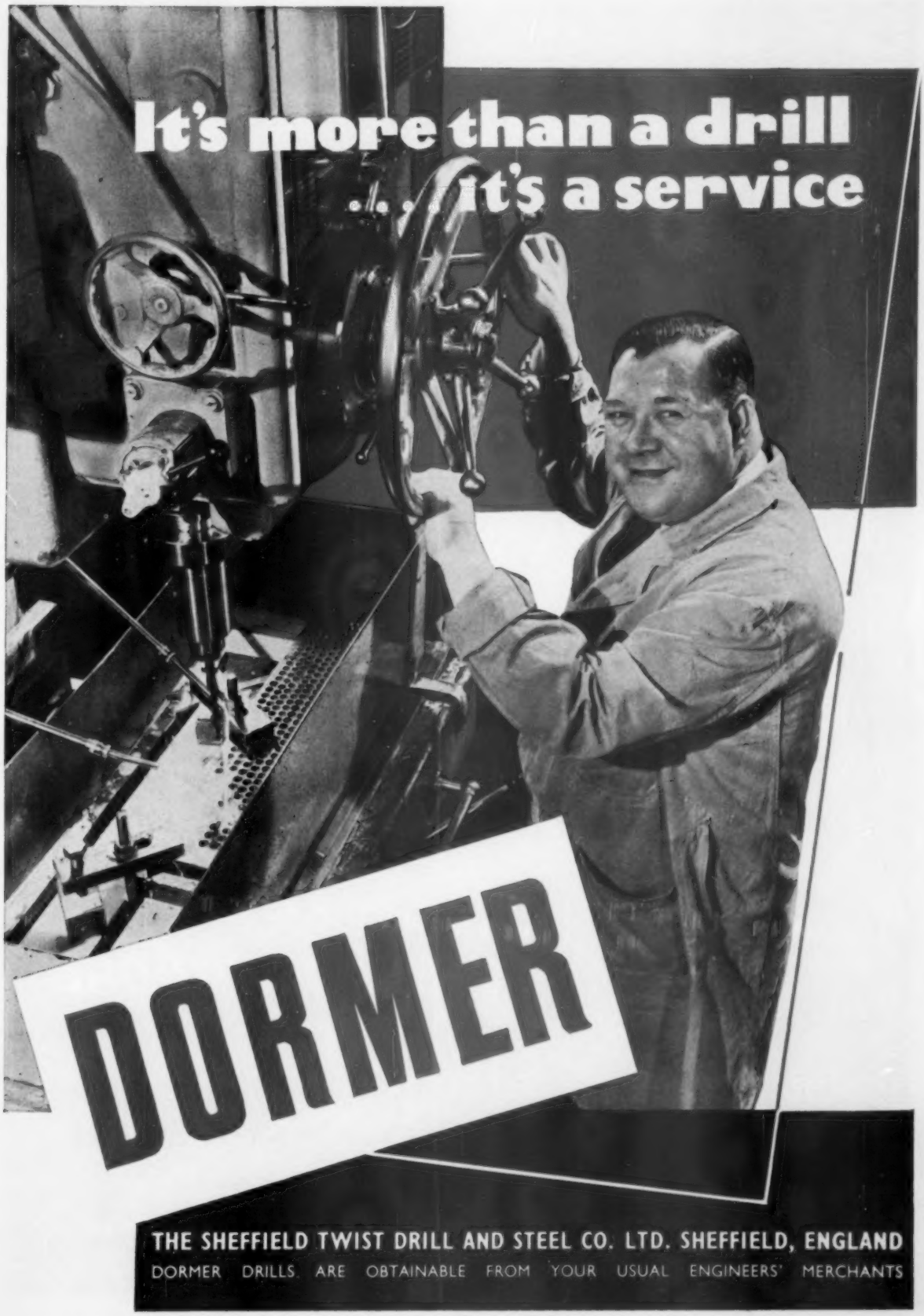
Recently introduced, the Saffire Combined Outfit has achieved outstanding success and widespread use in industry.

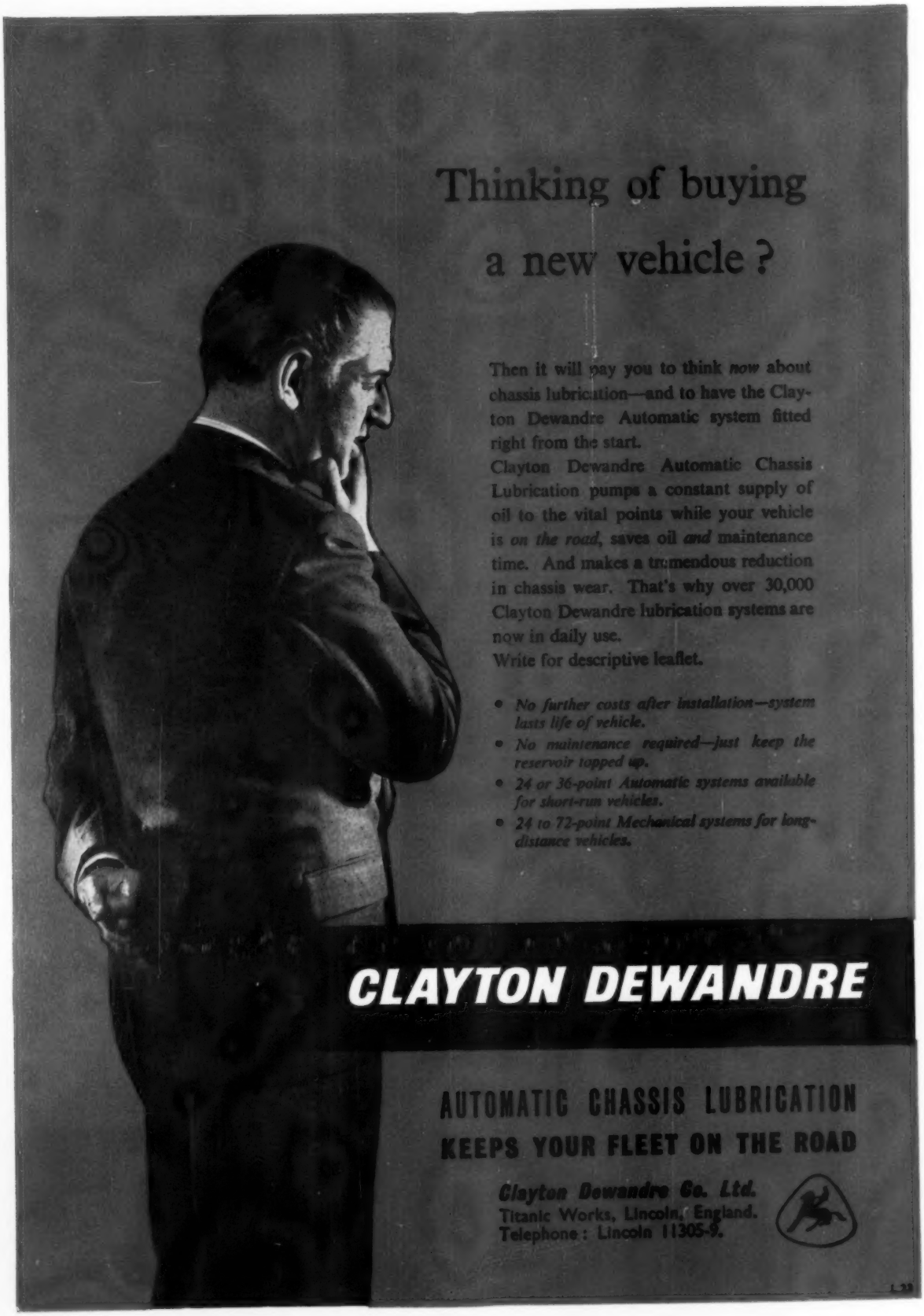
The Saffire, virtually 4 blowpipes in 1, is extremely efficient and economical in use. Here is a precision tool that has helped boost production for many thousands of users.

Buy the whole Saffire Outfit or just the common shank with the heads you need. Just consider how the Saffire Combined Outfit can increase *your own* production range and efficiency!

BOC **BRITISH OXYGEN**

British Oxygen Gases Ltd., Industrial Division,
Spencer House, 27 St. James's Place, London, S.W.1.


It's more than a drill
... it's a service
DORMER
THE SHEFFIELD TWIST DRILL AND STEEL CO. LTD. SHEFFIELD, ENGLAND
DORMER DRILLS ARE OBTAINABLE FROM YOUR USUAL ENGINEERS' MERCHANTS


Thinking of buying
a new vehicle?
Then it will pay you to think *now* about chassis lubrication—and to have the Clayton Dewandre Automatic system fitted right from the start.
Clayton Dewandre Automatic Chassis Lubrication pumps a constant supply of oil to the vital points while your vehicle is *on the road*, saves oil *and* maintenance time. And makes a tremendous reduction in chassis wear. That's why over 30,000 Clayton Dewandre lubrication systems are now in daily use.
Write for descriptive leaflet.
• *No further costs after installation—system lasts life of vehicle.*
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• *24 or 36-point Automatic systems available for short-run vehicles.*
• *24 to 72-point Mechanical systems for long-distance vehicles.*
CLAYTON DEWANDRE
AUTOMATIC CHASSIS LUBRICATION
KEEPS YOUR FLEET ON THE ROAD
Clayton Dewandre Co. Ltd.
Titanic Works, Lincoln, England.
Telephone: Lincoln 11305-9.
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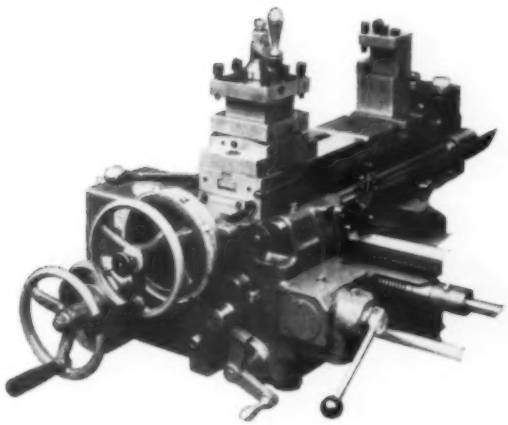
HERBERT

No. 5 SENIOR PREOPTIVE CAPSTAN LATHE *for chuck work up to* $15\frac{1}{2}$*" swing or bar work up to* $2\frac{1}{2}$*" diameter*



Salient features :

Preoptive Headstock eliminates idle time due to speed changing. Speeds pre-selected and engaged without stopping spindle.

Forged-steel cross slide. Quick-acting, self-indexing square turret.

Single lever operates longitudinal and transverse feeds. Independently reversible to those of capstan slide.

Longitudinal feed motion accurately controlled by barrel-type trip and dead stops.

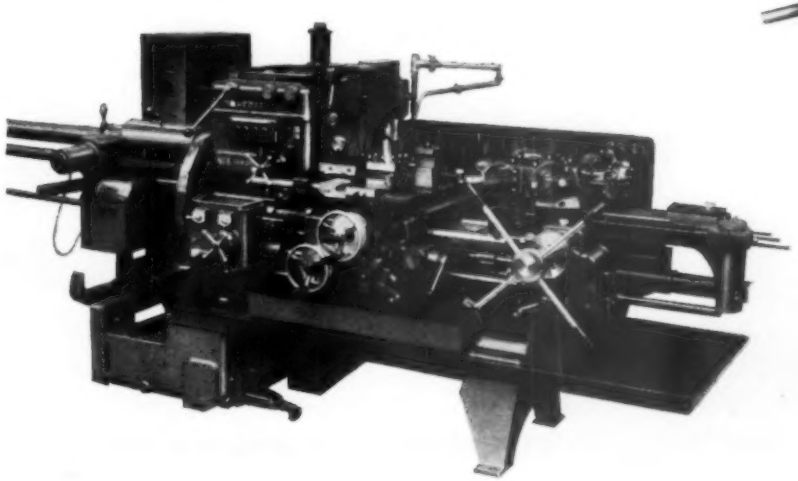
Single-shot lubrication to all enclosed mating surfaces of capstan slide and turret.

Turret is automatically clamped. Hollow construction permits bars to be passed through when required.

Single lever disengages automatic indexing mechanism and enables turret to be rotated by hand when required.

"Flamard" treated bedways and other wearing surfaces practically eliminate wear and ensure maintenance of original accuracy.

Available for Early Delivery

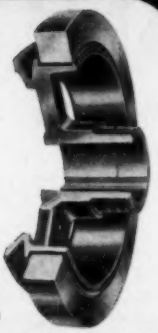


ALFRED HERBERT LTD., COVENTRY

AD 369

FLEXIBLE COUPLINGS

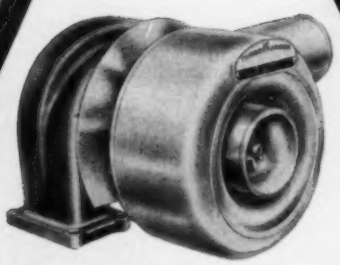
The Holset range covers all types of resilient couplings, including shear pin, slipping, spacer, spider, cardan shaft, turbine and low dynamic stiffness (soft) couplings for all powers and service conditions



NON-BONDED RUBBER CRANKSHAFT DAMPERS

A combined damper and pulley unit means lower costs on automobile applications. Increased reliability and freedom from bond failures. Designed to suit individual requirements.

Our Engineers are at your disposal to discuss these units in relation to your particular problems.



TURBOCHARGERS

Of advanced SCHWITZER design. With a background of proved reliability in the field. Largest number in service. Available in eleven standard models.

VISCOUS CRANKSHAFT DAMPERS

For Industrial, Locomotive and Marine Engines of any size and any power. Reduces torsional vibration amplitudes and stresses to the lowest possible values.

THE

HOLSET

ENGINEERING CO. LTD., TURNBRIDGE, HUDDERSFIELD

TELEPHONE: HUDDERSFIELD 7490 TELEGRAMS: HOLSET, HUDDERSFIELD

9399

—the **DeVlieg** *method effected*

savings of —26% in machining time

—69% in setting times

The above component is machined on a DeVlieg Jigmil in two set-ups, previously on a horizontal boring machine eight set-ups were necessary. Operations vary from precision boring a hole 1.251in. dia. by 6½in. long to milling the joint faces: in all, sixty-six operations are performed. The Jigmil method also considerably reduces the number of boring bars and miscellaneous equipment normally required for each operation on a horizontal boring machine.

The smallest of the range of DeVlieg Spiramatic Jigmils, known as the Herbert-DeVlieg No. 2B/36 is now built by us in a new specially-equipped plant at Lutterworth. The 2B/36 has vertical and horizontal capacities of 24in. and 36in. respectively; a 2¼in. dia. spindle.

Herbert-DeVlieg 2B/36 Spiramatic Jigmil.

ALFRED **HERBERT** LTD., COVENTRY — FACTORED DIVISION, RED LANE WORKS

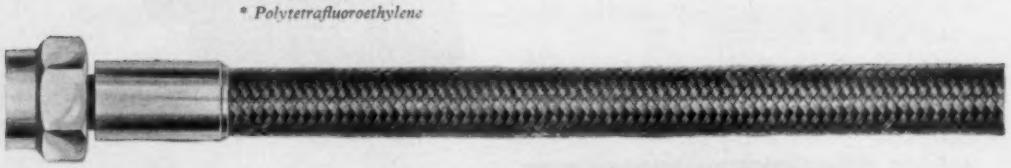
AD.401

Have you a pipe problem

better see DUNLOP — the Top experts

Specialists in the design, manufacture and installation of reinforced high and low pressure Rubber, P.T.F.E.* and Fleximet (Stainless Steel) Flexible Pipes.
Dunlop technicians are available to advise on all problems concerning the installation and use of flexible pipes. Details from H. S. Perrey, Dunlop Rubber Co. Ltd., St. Georges Road, Coventry. Telephone 64171.

* *Polytetrafluoroethylene*



DUNLOP *MAKE PIPES BETTER TO LAST LONGER*

BH 90*

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I understand Ransome & Marles make a special study of lubrication problems?

We do indeed. A bearing's performance is governed by correct lubrication as much as by correct design and materials. The cage location area is one of vital importance. The lubricant must also protect the highly finished surfaces from corrosion and help to dissipate any undue heat. To fulfil these requirements, we have a team of lubrication specialists at work.

What special lubrication problems do they have to deal with?

Our Technical Department study each case individually before making their recommendations. They may advise on grease for horizontal or vertical shafts, with the correct housing design and method of packing. If oil is used, the recommendation may involve lubrication by oil splash, a controlled oil level, drip feed or wick feed, and so on. All the time, of course, the various oil companies are developing new lubricants and these we subject to stringent tests before we recommend them for any application.

What about lubrication at ultra-high speeds?

Research into this is continuous. Operating speeds, loads and temperatures are steadily rising and every week brings fresh problems for solution. Aircraft and guided missiles are the obvious—but by no means the only—instances. Speaking generally we recommend lubrication by oil flood or vapour mist for the very highest speeds. We have built up extensive data on this and allied problems. If you get in touch with our Technical Department they'll be only too glad to talk lubrication with you.

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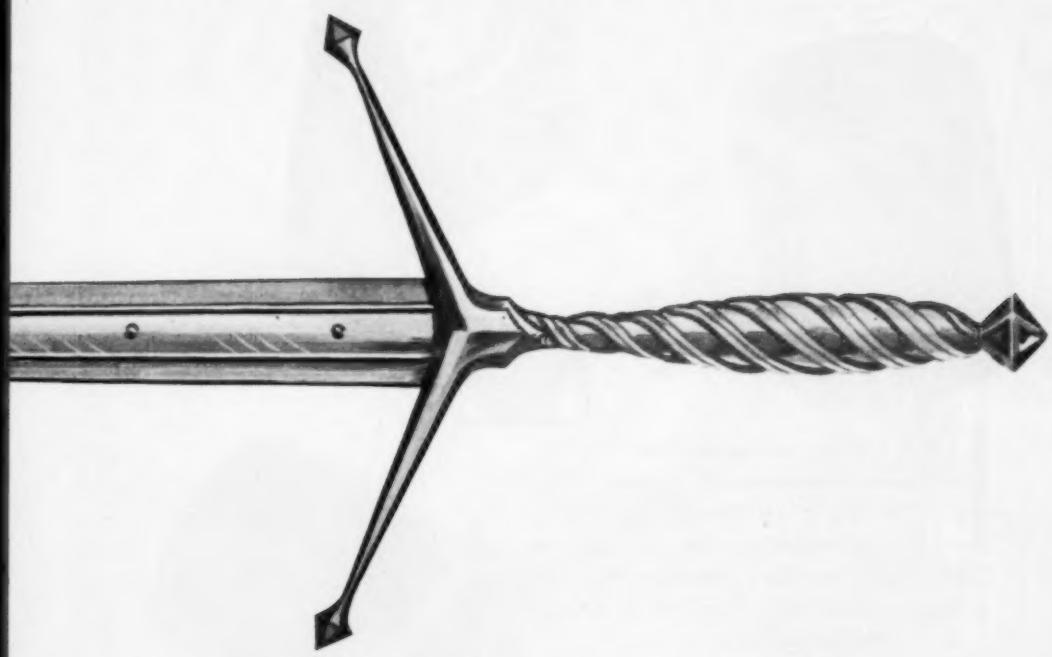

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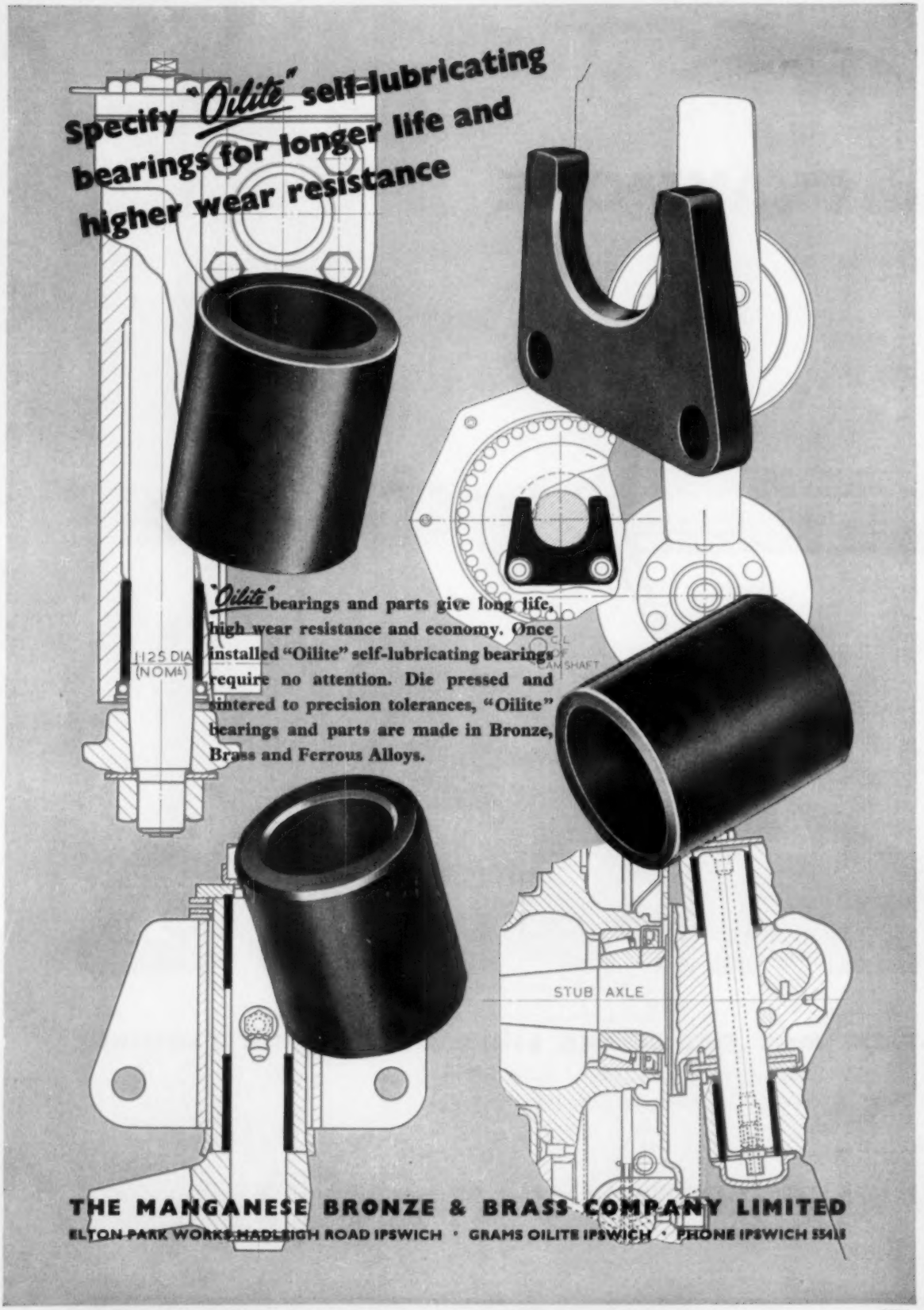
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This illustration shows external superfinishing on Gudgeon Pins in the Patricroft works of L. Gardner & Sons Limited, the well-known oil engine builders. Two further machines are employed in the same factory for high precision bore finishing on cylinder blocks.
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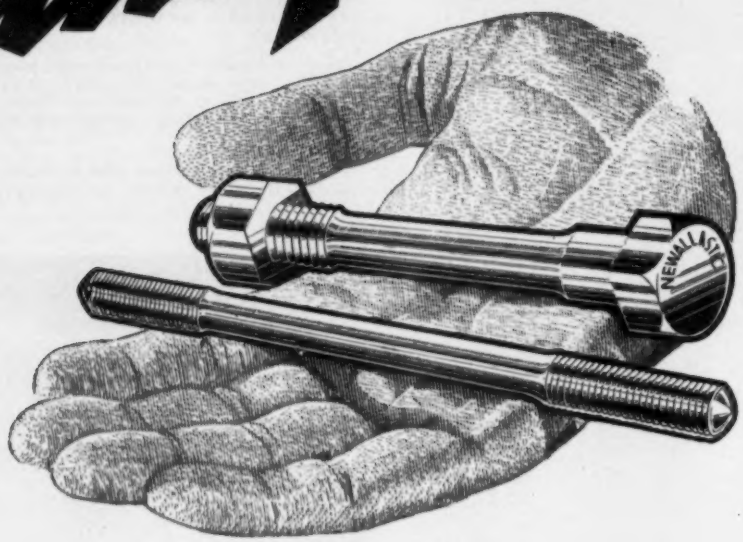

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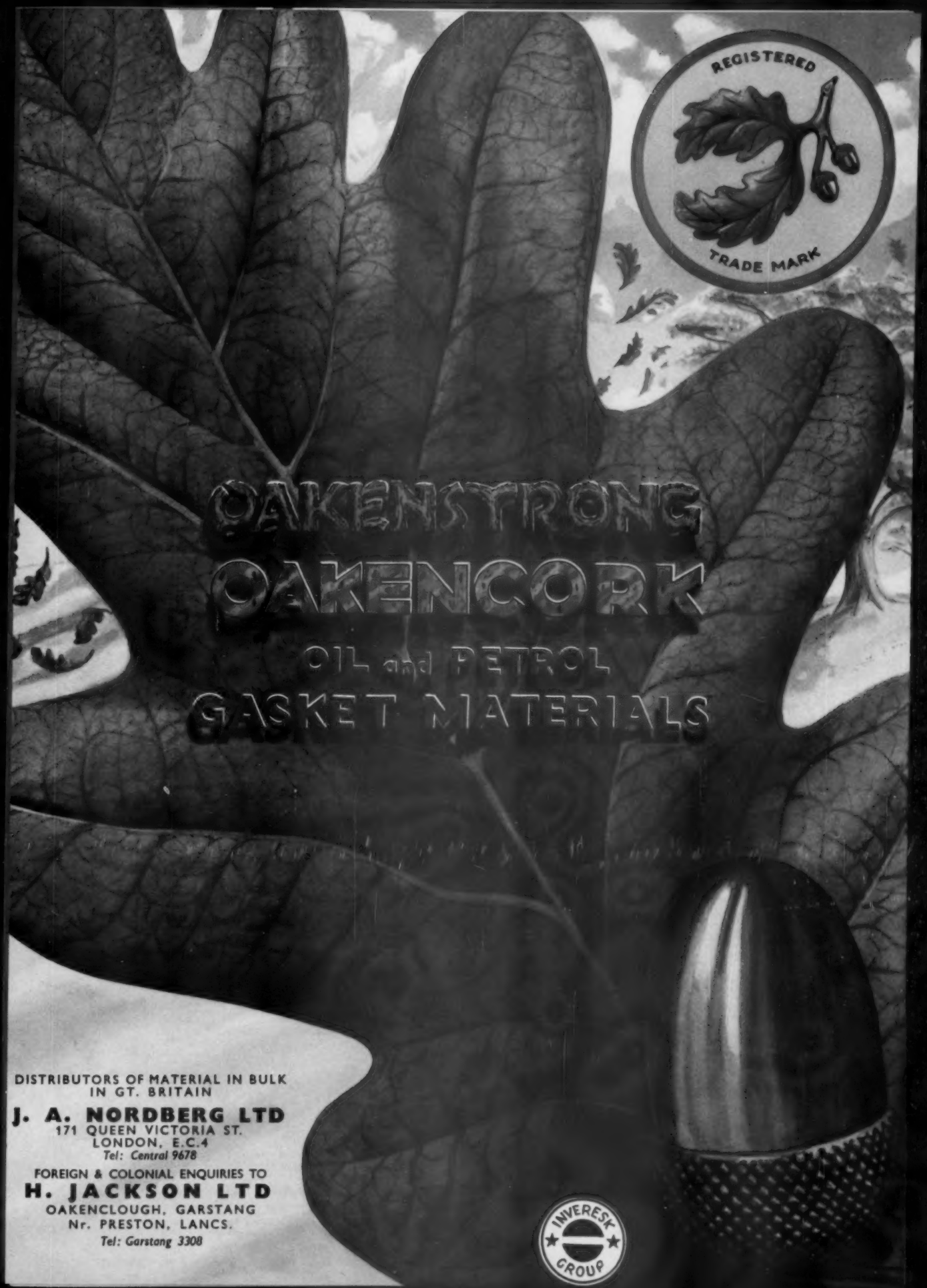

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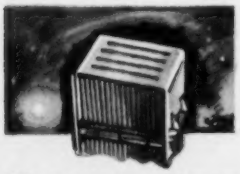

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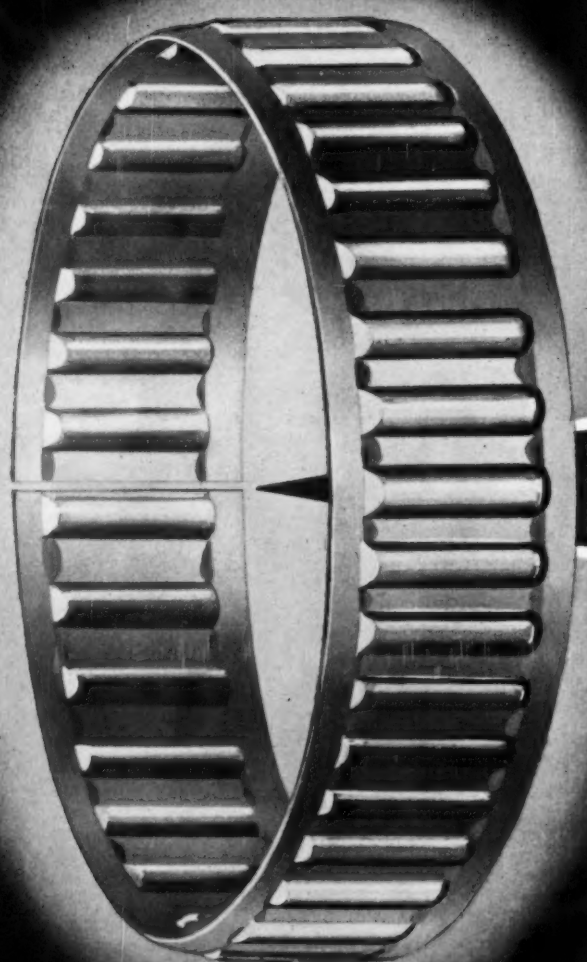

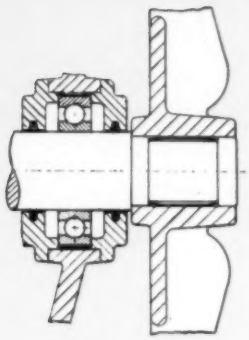

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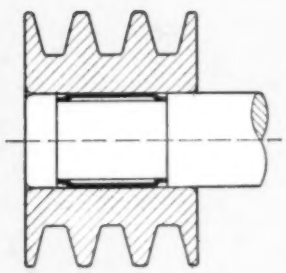

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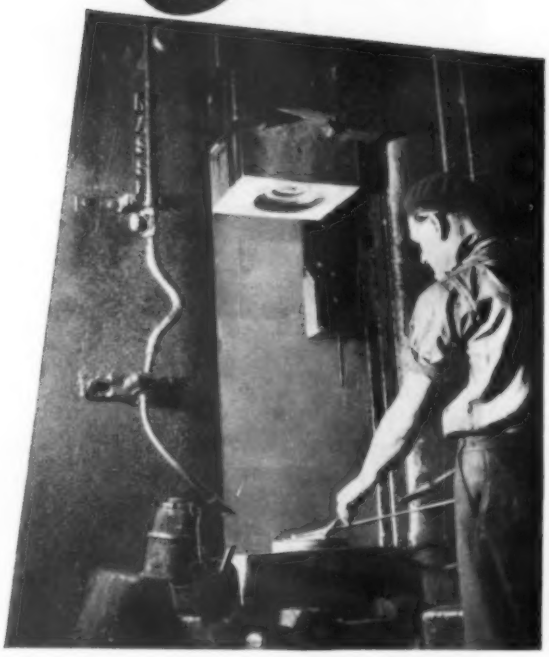

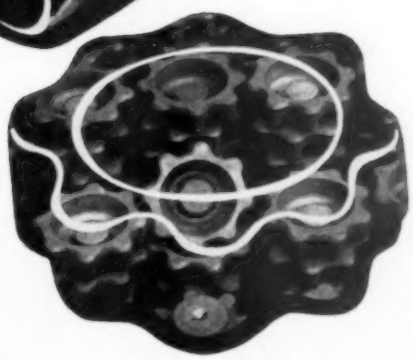

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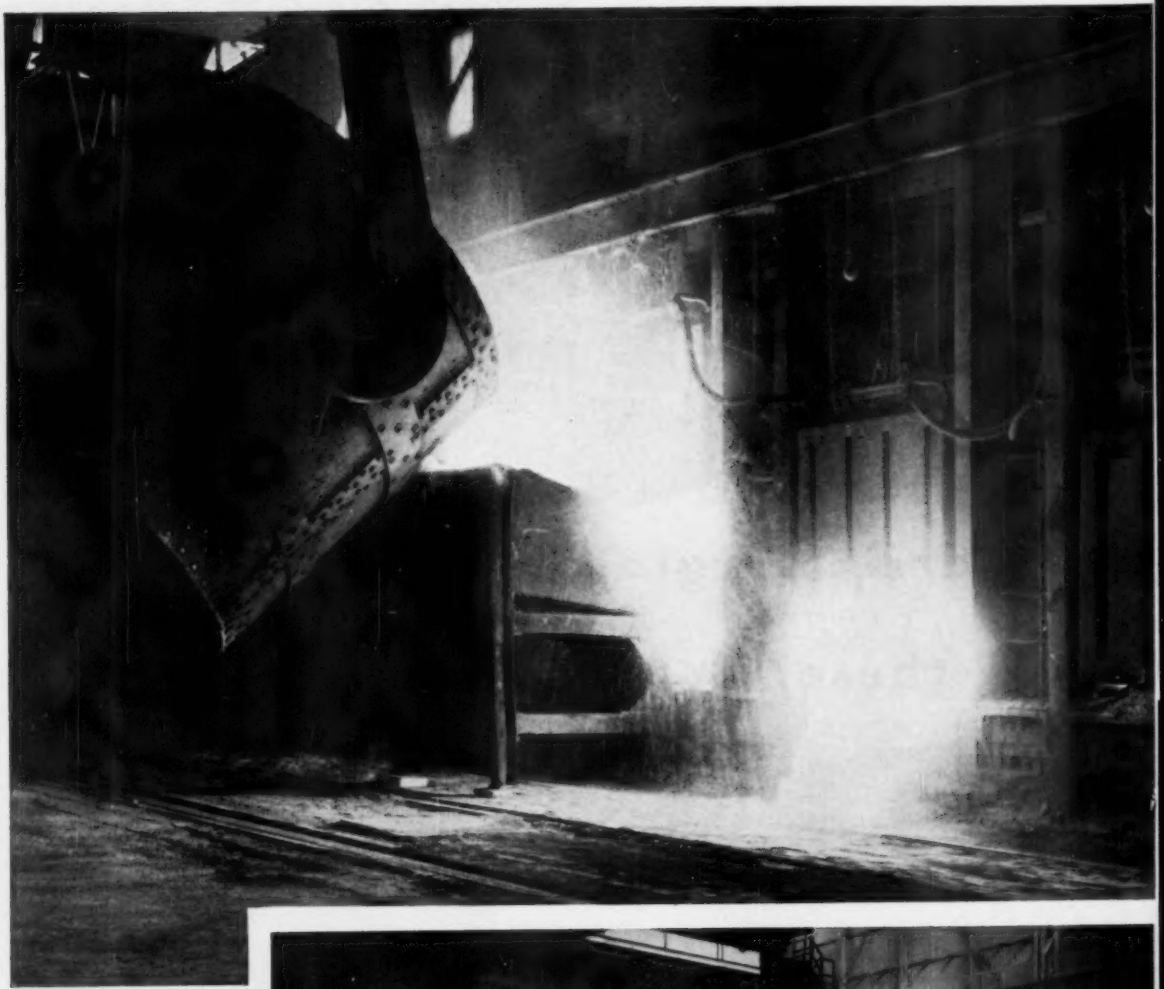
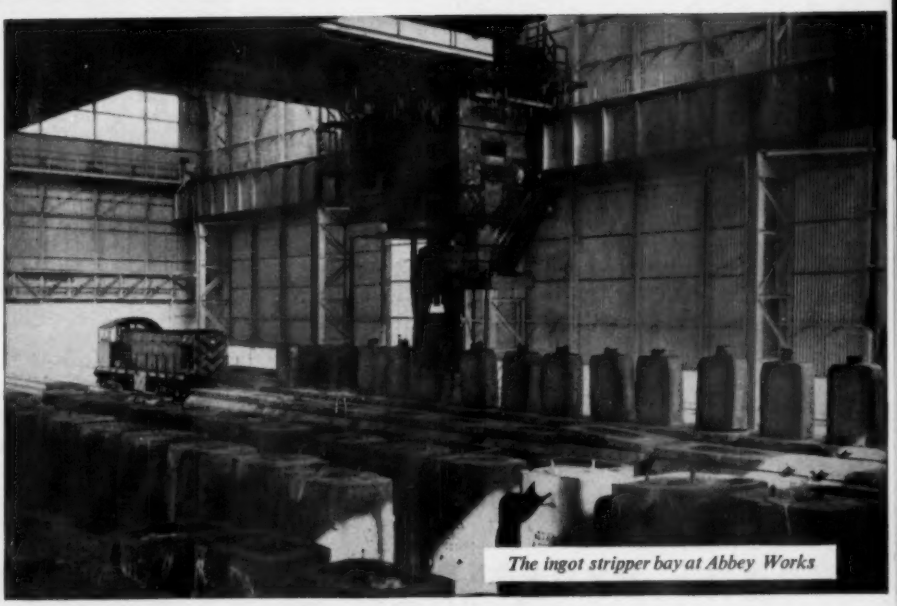


Molten iron being charged into an open hearth furnace at Abbey Works



The ingot stripper bay at Abbey Works

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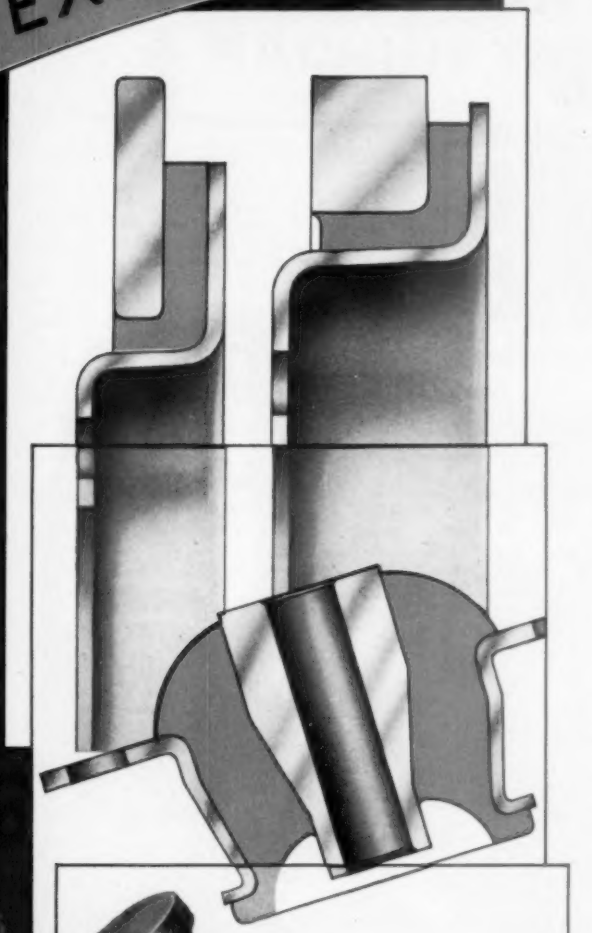

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Every Metalastik component—whatever its function—benefits from the experience we have gained in solving previous problems, and in its turn paves the way for further advances.

Metalastik leadership is the outcome of this deep-rooted specialization and has established rubber-bonded engineering as a necessity to the motor industry.

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Reversible jaw plates for irregular shapes.

Standard range includes 4", 6" and 8" jaw widths.

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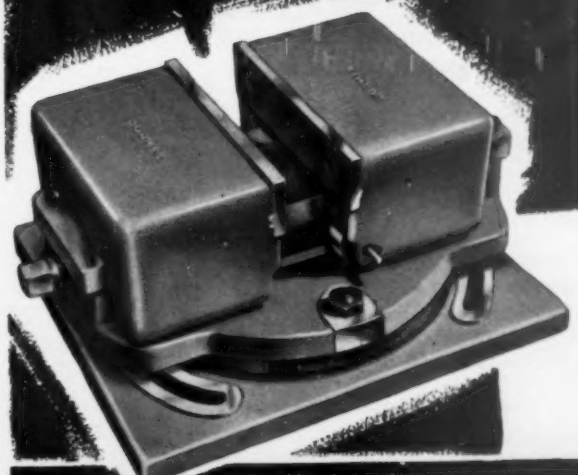

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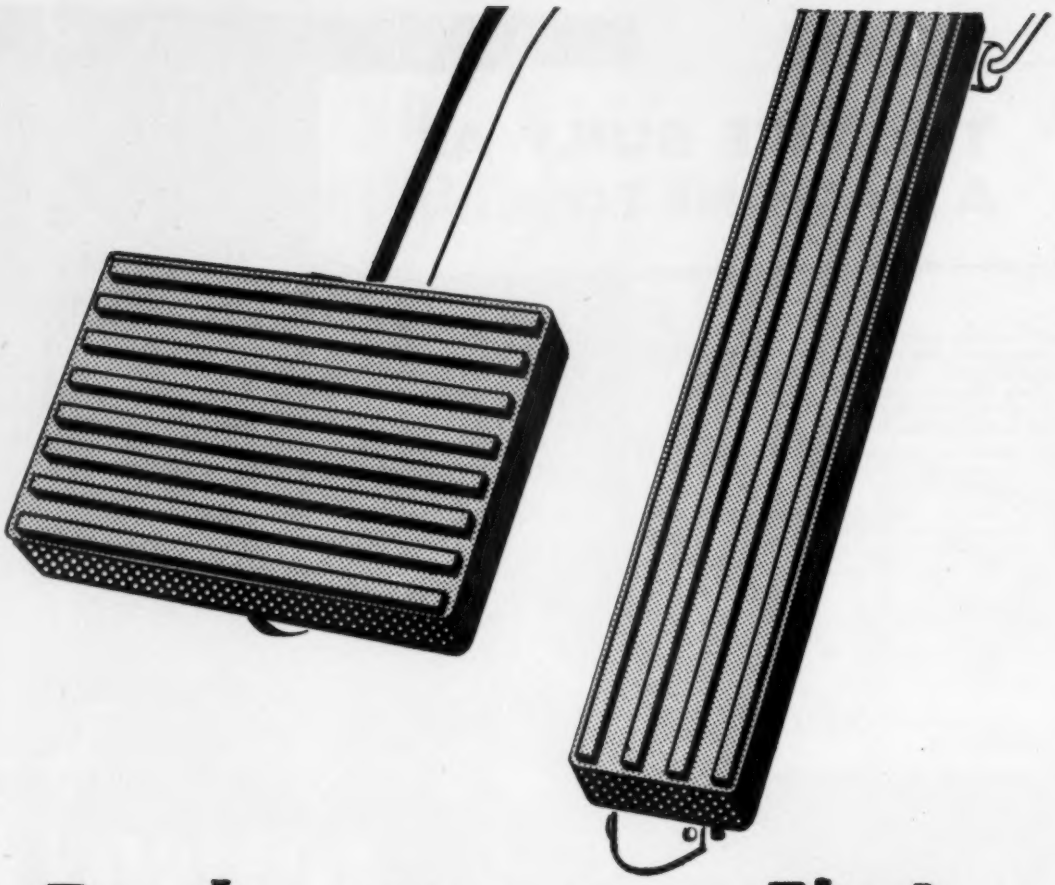

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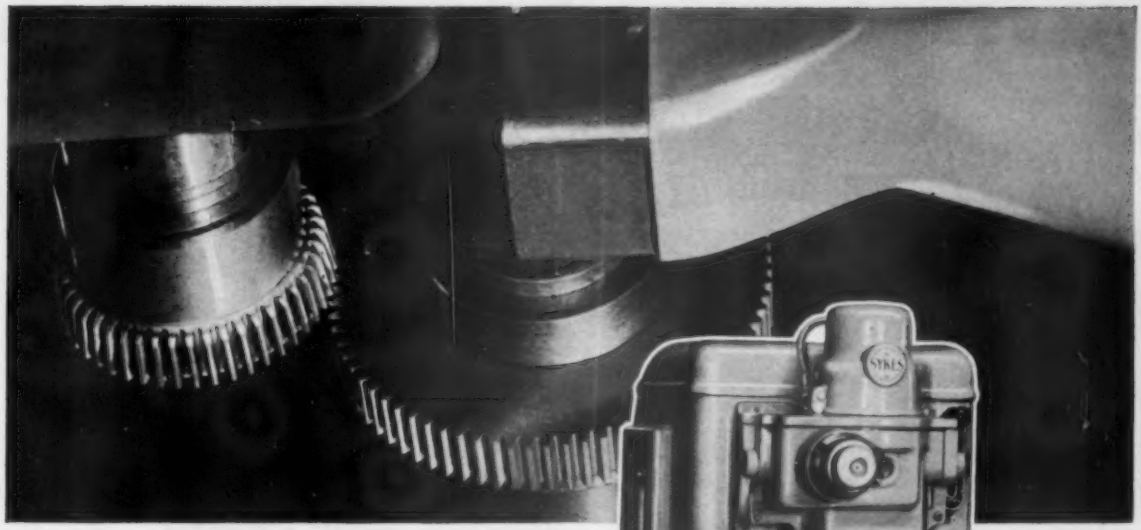

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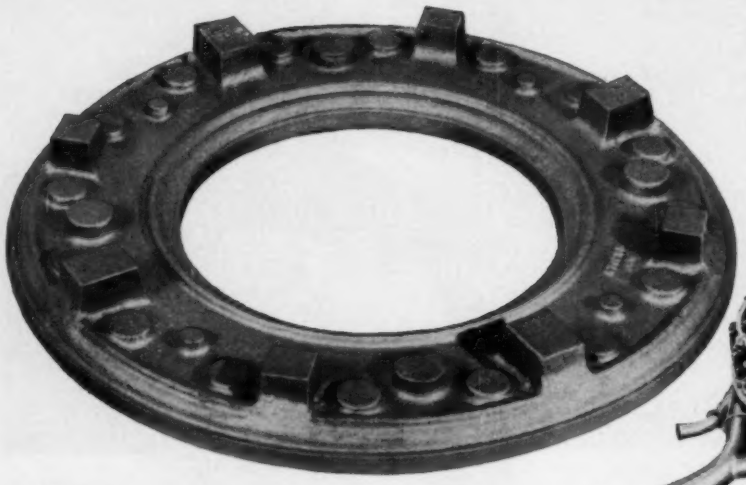

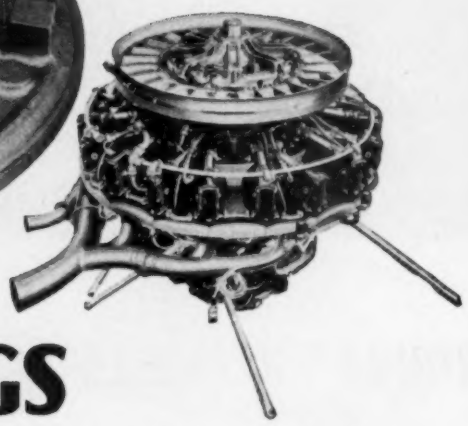

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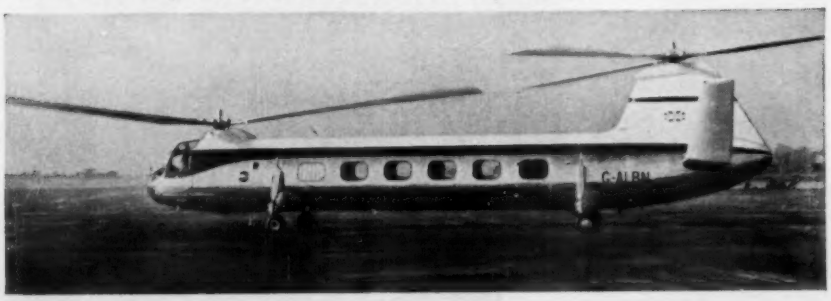

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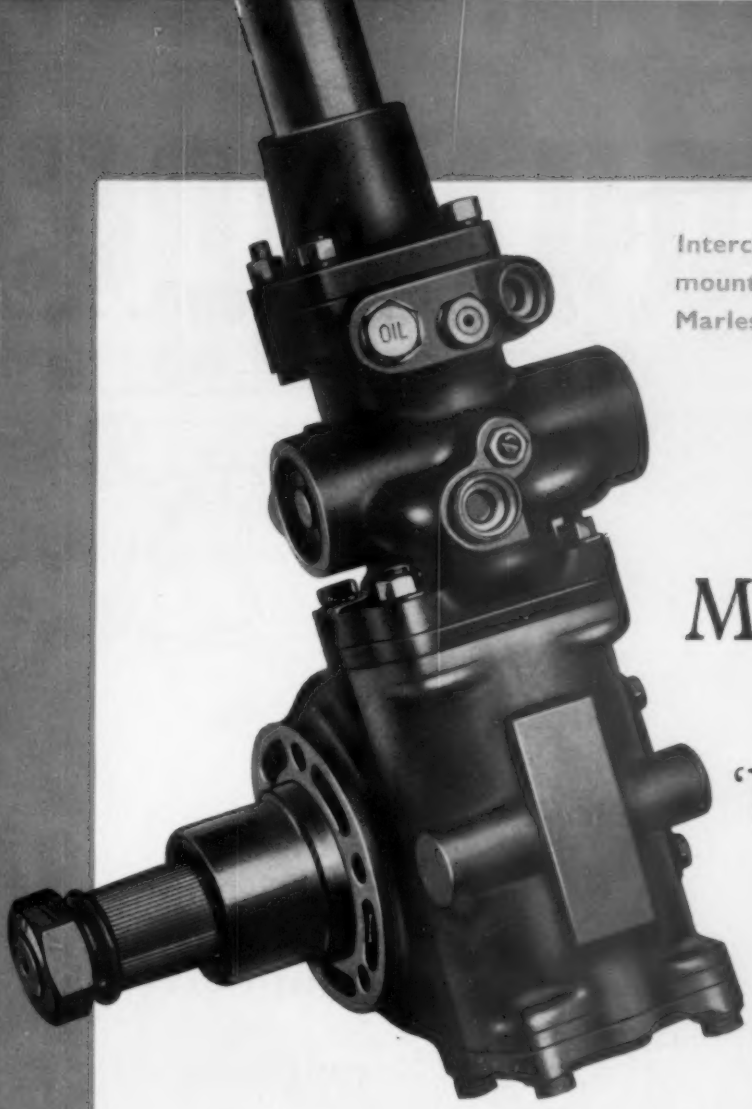

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This latest type 4 unit embodies the wide experience of Marles in power-steering, and consists of a 2-valve box mounted on the top of the standard Marles 861 manual gear unit.

The type 4 Universal unit shown above, the type 3 Universal unit and the standard manual unit are all interchangeable on the same mountings.

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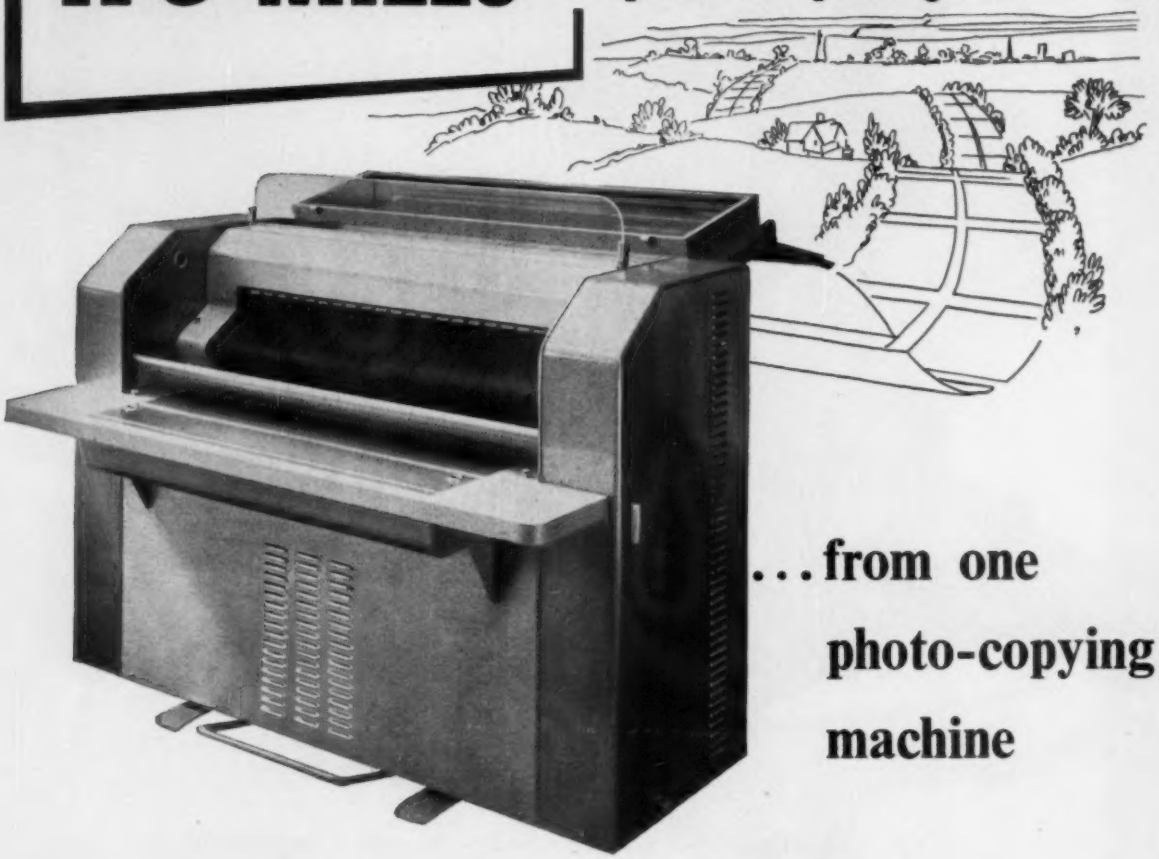

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Full range of Solid and Flexible Roller Bearings available from 10 mm. to 350 mm. shaft diameter. Ask for catalogue *RFX*.

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All interchangeable with and equivalent to bearings of American type and manufacture.

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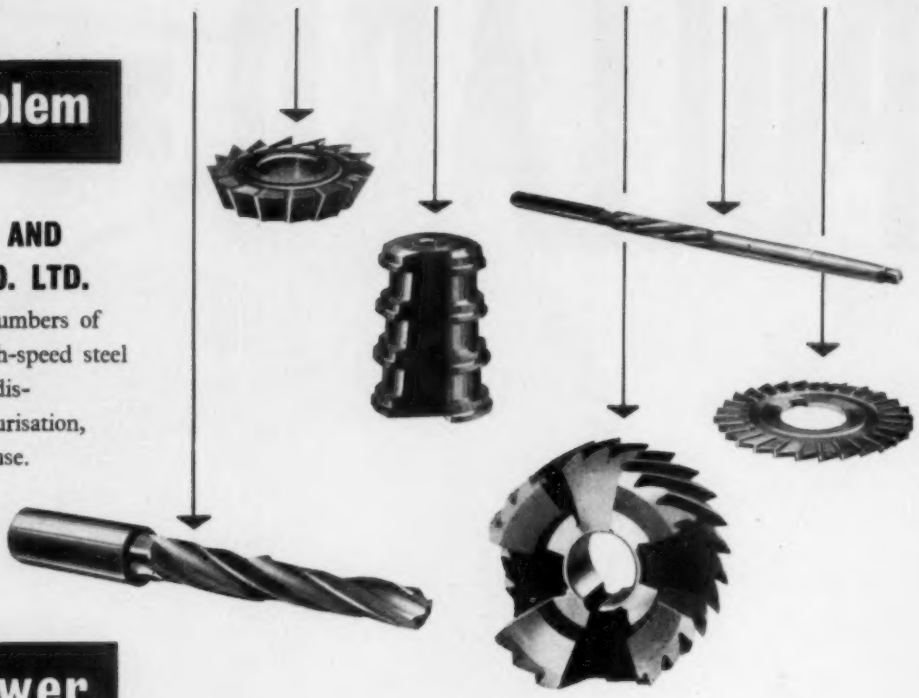
The problem

set by
ALDRIDGE TOOL AND ENGINEERING CO. LTD.

To heat treat large numbers of different kinds of high-speed steel tools, with minimum distortion and no decarburisation, to ensure long life in use.



the answer

given by the 'Cassel' Heat Treatment Service

After suitable preheating in air and then in a 'Cassel' P.S.760 salt bath, the tools are transferred to the high temperature 'Cassel' H.S.970 bath, in which they are soaked for the required time, and then quenched in a 'Cassel' Q.S.540 bath and finally air cooled. Secondary hardening treatments are also carried out in Q.S.540. The 'Cassel' furnaces and salts provide the most convenient and speedy method for obtaining optimum results.

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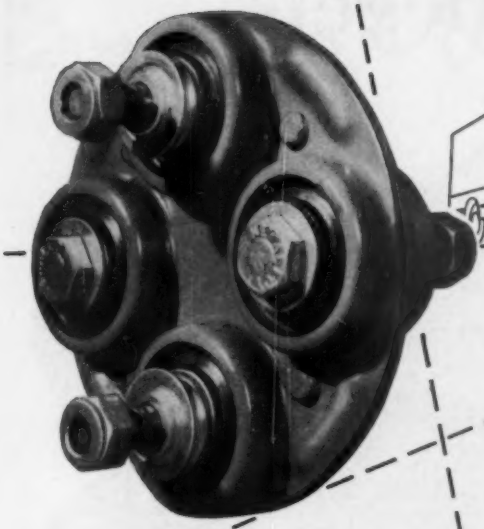

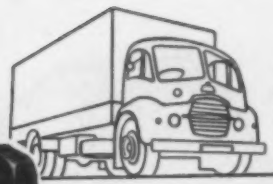

"100,000 miles without any attention to coupling, apart from routine check-over for looseness and play . . . thousands of miles of life remaining." This is typical of reports from operators of transport fleets.

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Spacing the shock-absorbing rubber bushes apart in Layrub couplings are two pressings by FORGINGS & PRESSWORK LTD. The bonded-rubber bushes are press fitted in their locations: Stress No. 1. The whole torque transmitted from gearbox to drive axle is transmitted through the pressings: Stress No. 2. FORGINGS & PRESSWORK LTD specialise in producing pressings able to withstand high stress.

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Corrosion-Resisting Aluminium Alloy

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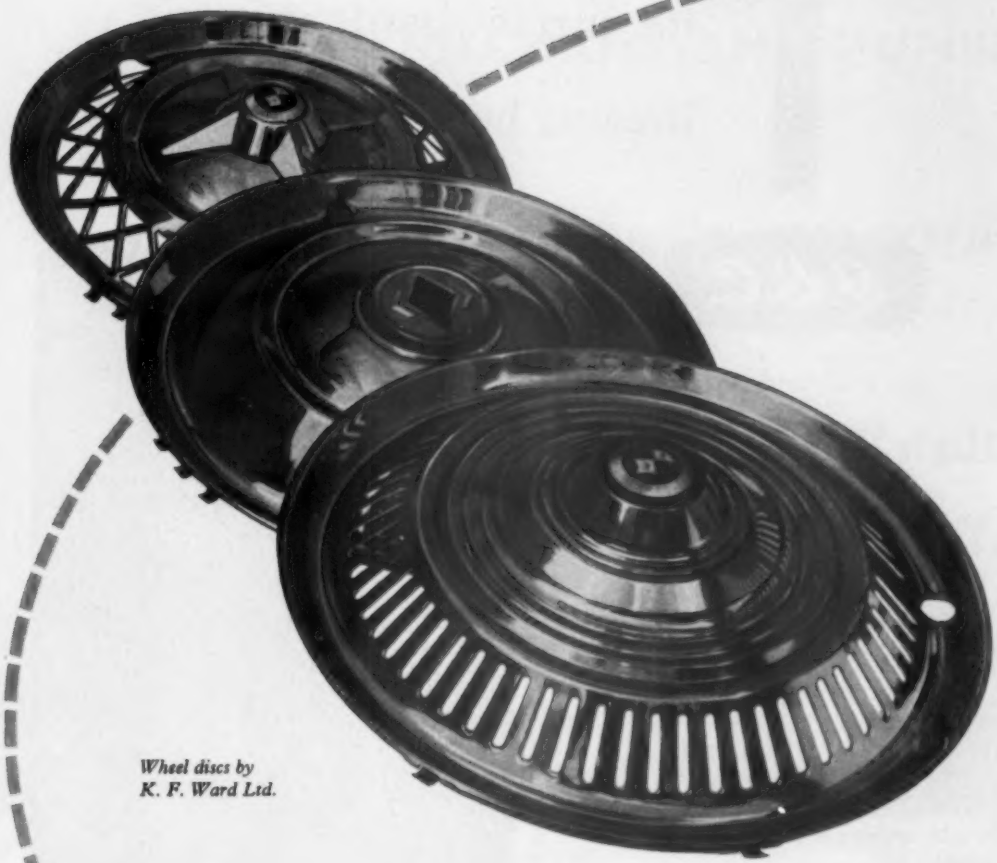

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wheel discs made from Stainless Steel

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Each heater has a power output control to adjust impedance matching of the loads giving optimum conditions for a wide range of applications.

The work coils are easy to make and easy to interchange.

Tank circuit has a high kVA rating, allowing the full available power to be applied to very difficult loads.

Work table supports are fitted on the lower front panel and retracting trunnions are provided at the base to facilitate movement.

Finished in stove-enamelled Oxford blue with front panel stove-enamelled polychromatic silver. Output control guide plate and work table supports chromium plated.

Write for further information.

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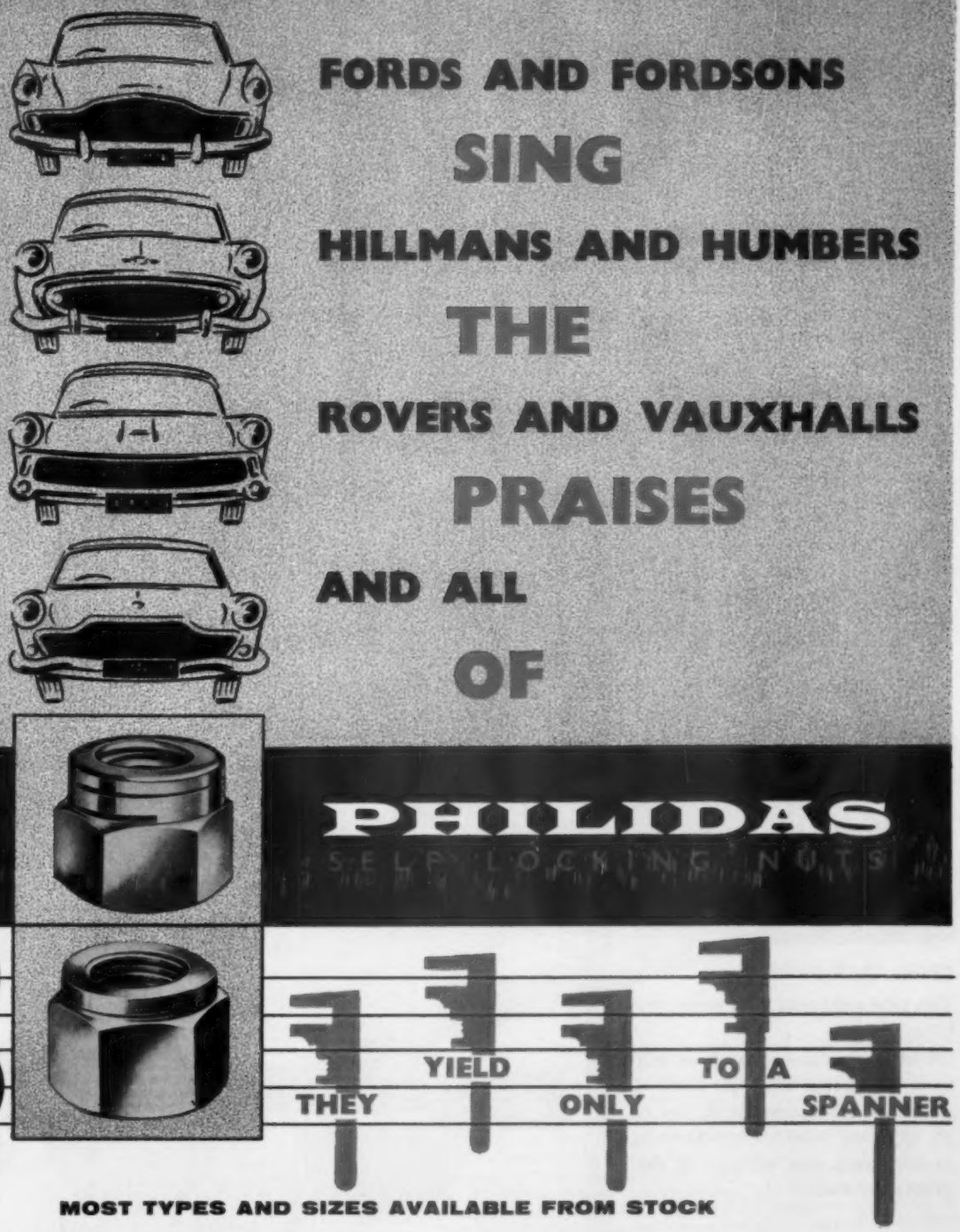

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AUTOMATIC LEVELLING

A suspension incorporating Andre Air Springs and levelling valves assures that the floor of the vehicle is always parallel to the axle, thus uneven loading and severe crown road conditions etc. are overcome, giving a more pleasant and easy ride for the driver. For Passenger Vehicles step heights remain constant irrespective of load.

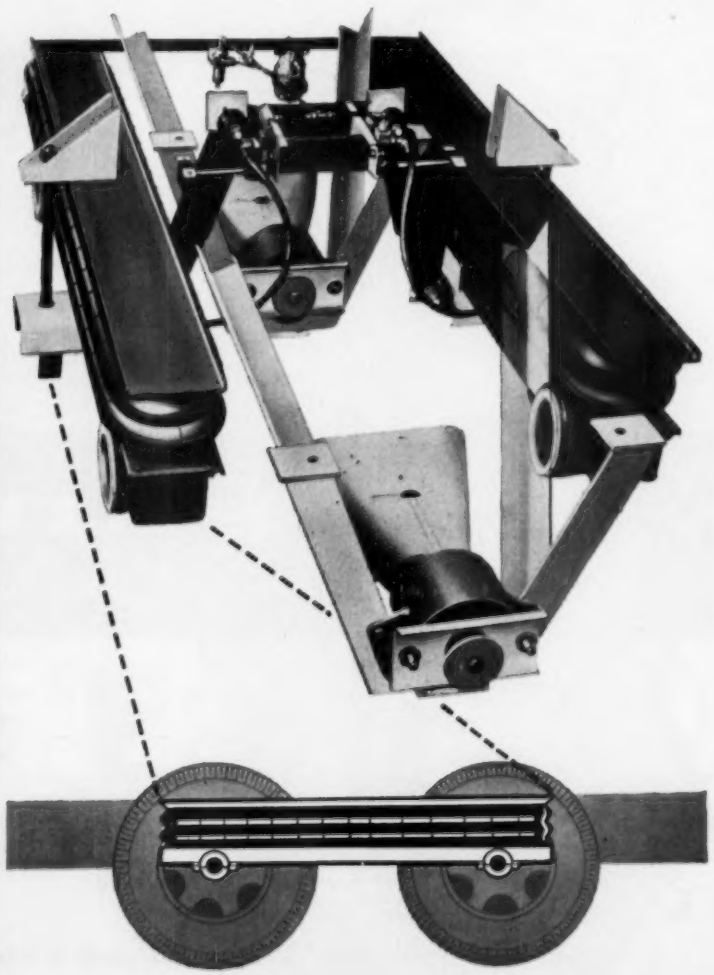
ALWAYS THE SAME RIDE WHETHER LIGHT OR LADEN VEHICLE

A feature of air springing is that, due to the action of the levelling valves, the position on the load deflection graph remains constant irrespective of load; consequently the frequency remains the same for all conditions of service. This also has the effect of eliminating bouncing due to resonance conditions, thus reducing maintenance not only of the suspension but chassis and body. It also affords greater protection for the goods or passengers being carried.

INCREASED SAFETY

This ideal suspension gives greater tyre life.

We invite you to approach us with your problems, when we shall be pleased to co-operate with you on all technical matters appertaining to this great new advance in suspension systems.



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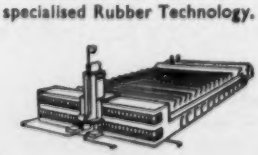

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ANDRE RUBBER COMPANY LIMITED

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The C.A.V. Automatic Electrical Gear Change Equipment enables a driver to concentrate on his job—safe control of the vehicle. It relieves him of all gear-changing operations, which for a public service vehicle on a busy route may number 4,000 per day. Gear changes are effected strictly in accordance with road speed and engine torque, so that driving is by accelerator and brake only. It makes the driver's job easier and reduces wear and tear on the vehicle. Neutral is automatically selected as the vehicle slows to a stop, and reverse cannot be selected accidentally. An overriding control permits the manual selection of gears if and when required. This equipment is applicable to vehicles with direct-acting epicyclic gear-boxes, using either pneumatic or electro-hydraulic operation.

C.A.V. Automatic GEAR CHANGE Control Equipment

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Fuel Injection and Electrical Equipment

C.A.V. LIMITED, ACTON, LONDON, W.3

C.A.V.

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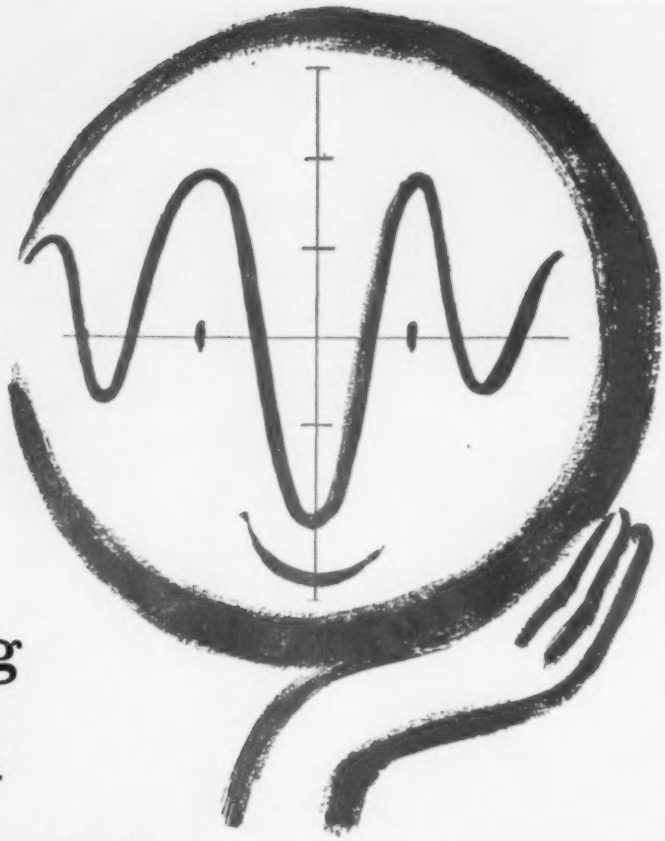

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If you are experienced in the design of high quality instruments, our Technical Director would be glad to hear from you.

FOR USE IN ELECTRONICS? From the wide range of single and double-beam instruments, a model is available to suit the requirements of all sections of this expanding industry.

IN INDUSTRY? Diverse industries are finding solutions to their design and production difficulties with the aid of the Cathode Ray Oscillograph. Our Technical Advisory Service will be pleased to help you with your specific problem.

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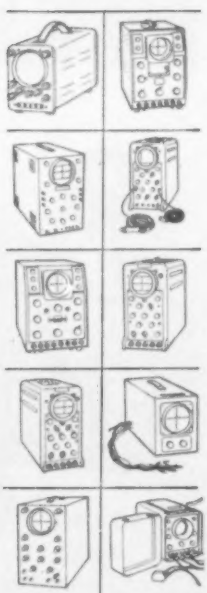

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The Instrument Company of the Cossor Group

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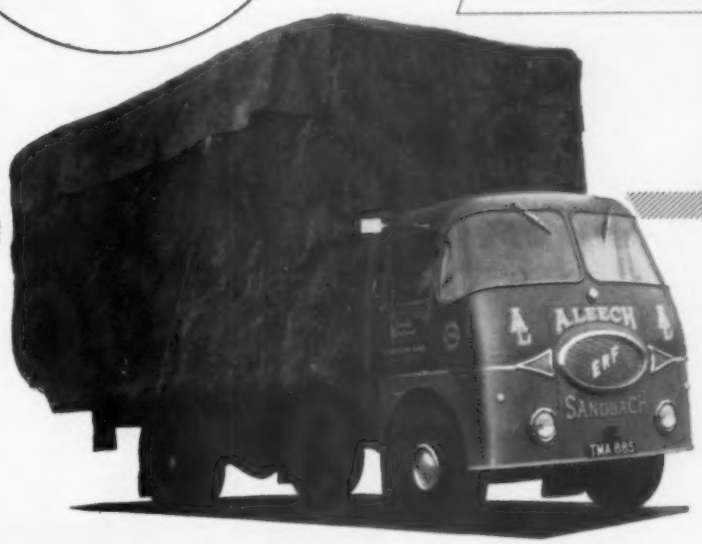
EATON

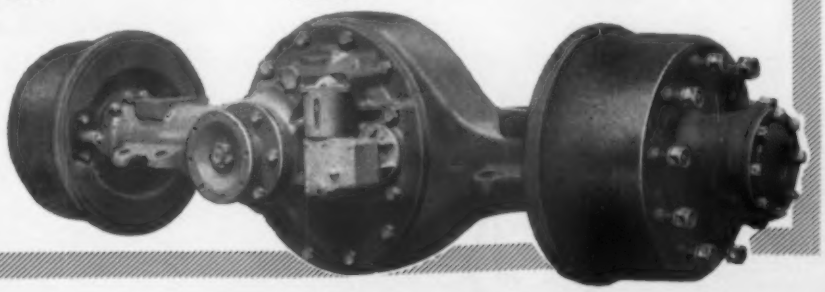
2-SPEED AXLES



By fitting the Eaton two-speed axle as standard on their successful 13 ton model 44G, E.R.F. provide plenty of power for the 'tough spots,' good average speeds on every trip and, when running light, high speeds at low engine revs. A single and a double reduction in the one axle unit provides a suitable gear for every condition of road and load.

The Eaton two-speed axle cuts fuel consumption, reduces wear and tear on engine and transmission and your maintenance costs are at a minimum.

That is why operators today insist on Eaton and why the top manufacturers fit the two-speed axle that adds something to the finest vehicles.



EATON AXLES LIMITED

VICTORIA ROAD, GREAT SANKEY, WARRINGTON, ENGLAND

In association with
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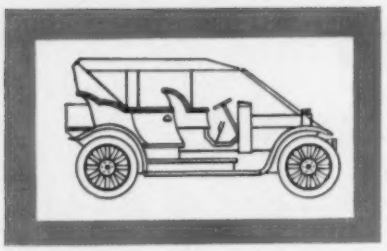

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span the history of an era

. . . and help to make that era memorable.
The continuing success of Sterling Metals is due to their ability
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Spiral-bevel drive casing and cover
in Z5Z Magnesium-Zirconium Alloy
for record-breaking M.G. EX.181 car.
By courtesy of British Motor Corporation.

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STERLING METALS LTD
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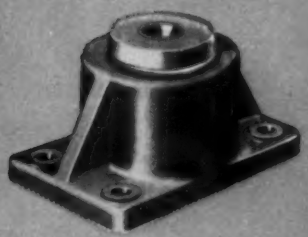
General type (triangular flange)

Pedestal assembly



Pedestal mounting

Frustacon type

FN type

Instrument type (pedestal flange)

Instrument type (square flange)

Ring-stud mounting

Bonded stud mounting

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'SILENTBLOC' rubber-metal mountings are the accepted means of insulating almost anything from vibration—from small and delicate instruments to multi-ton drop-hammers. If you have a vibration problem, bring it to us as pioneers and far and away the leaders in the use of rubber in engineering. Technical information always available from *Silentbloc Limited, Manor Royal, Crawley, Sussex. Telephone: Crawley 2100.*

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ANDRE RUBBER CO. LTD. — A SILENTBLOC COMPANY

Pioneers of Rubber in Engineering

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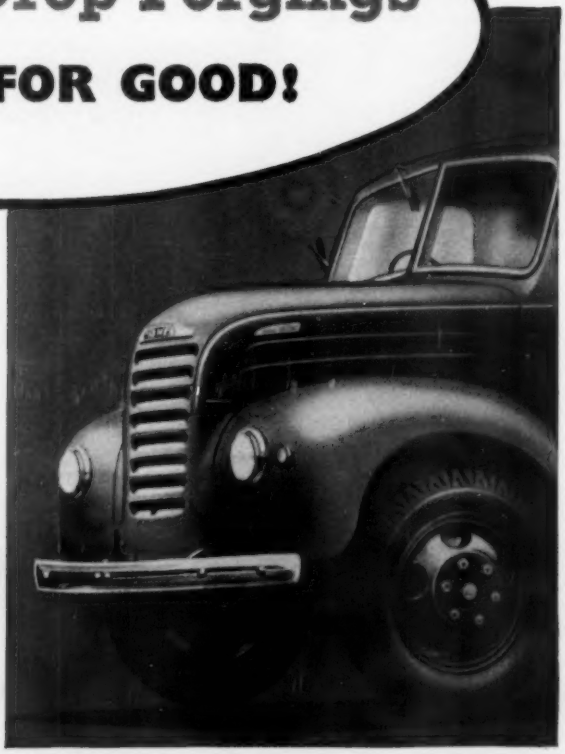
Smethwick Drop Forgings

...FITTED FOR GOOD!



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Vertical Internal
Broaching Machine
broaching Crown Wheels
(bore 7¼″/9″ diameter)
fully automatic loading
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Capacity : 5/50 tons.
Broach lengths : 42/68 inches.
Can be supplied for
1, 2, 3 or 4 stations.

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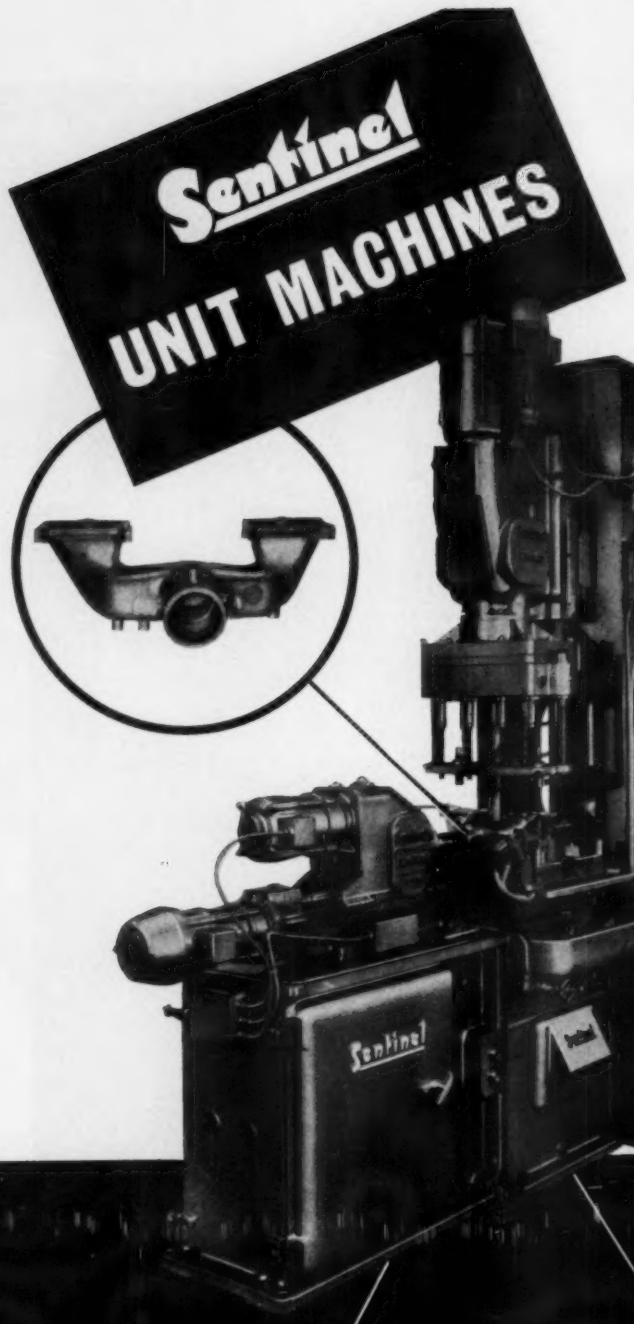
Sentinel UNIT MACHINES

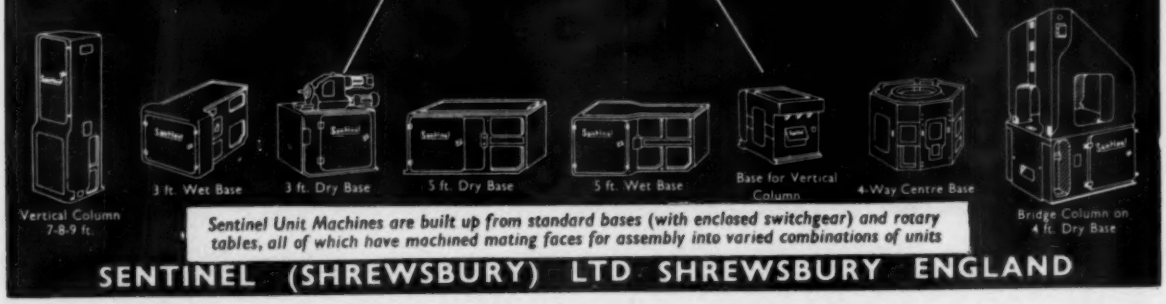
FAST VERSATILE ECONOMICAL



SENTINEL UNIT MACHINES incorporating the Renault-France system electro-mechanical heads.
Built for—Drilling, Boring, Facing and Chamfering. 8 different types of Manifolds (see *inset*). Two manifolds are loaded, pneumatically located and clamped.
Press a button to start—and in less than 30 seconds the machining cycle is completed!

AN EXAMPLE OF FLEXIBILITY

This Unit Machine comprises a
3 ft. Dry Base, and an EMH 10 with Boring, Facing and Chamfering Tools.
3 way Centre Base.
4 ft. Dry Base, and an EMH 10 with Boring, Facing and Chamfering Tools.
Bridge Column, and an EMH 20 with a 12 multi-spindle head.


Vertical Column 7-8-9 ft.
3 ft. Wet Base
3 ft. Dry Base
5 ft. Dry Base
5 ft. Wet Base
Base for Vertical Column
4-Way Centre Base
Bridge Column on 4 ft. Dry Base

Sentinel Unit Machines are built up from standard bases (with enclosed switchgear) and rotary tables, all of which have machined mating faces for assembly into varied combinations of units

SENTINEL (SHREWSBURY) LTD SHREWSBURY ENGLAND

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And so it is with springs.

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But it has taken nearly two centuries of skill and devotion to achieve so great a reputation for reliability that—ironically enough—the greatest compliment paid to Salter Springs is that you can forget them!

FOR TOP PERFORMANCE—SPECIFY

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THE **ALL-ACTION** SPRINGS

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WEST BROMWICH · ENGLAND
Established 1760

We are proud that over the years we have been closely associated with Rolls-Royce and Bentley, supplying them with Pistons, Gudgeon Pins and Rings. We also produce the Turbine Blades used in the Rolls-Royce Conway and Dart turbine engines.

The same high standard of craftsmanship and precision engineering goes into all our products for both the manufacturing and replacement trades.

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HEPWORTH & GRANDAGE LTD.
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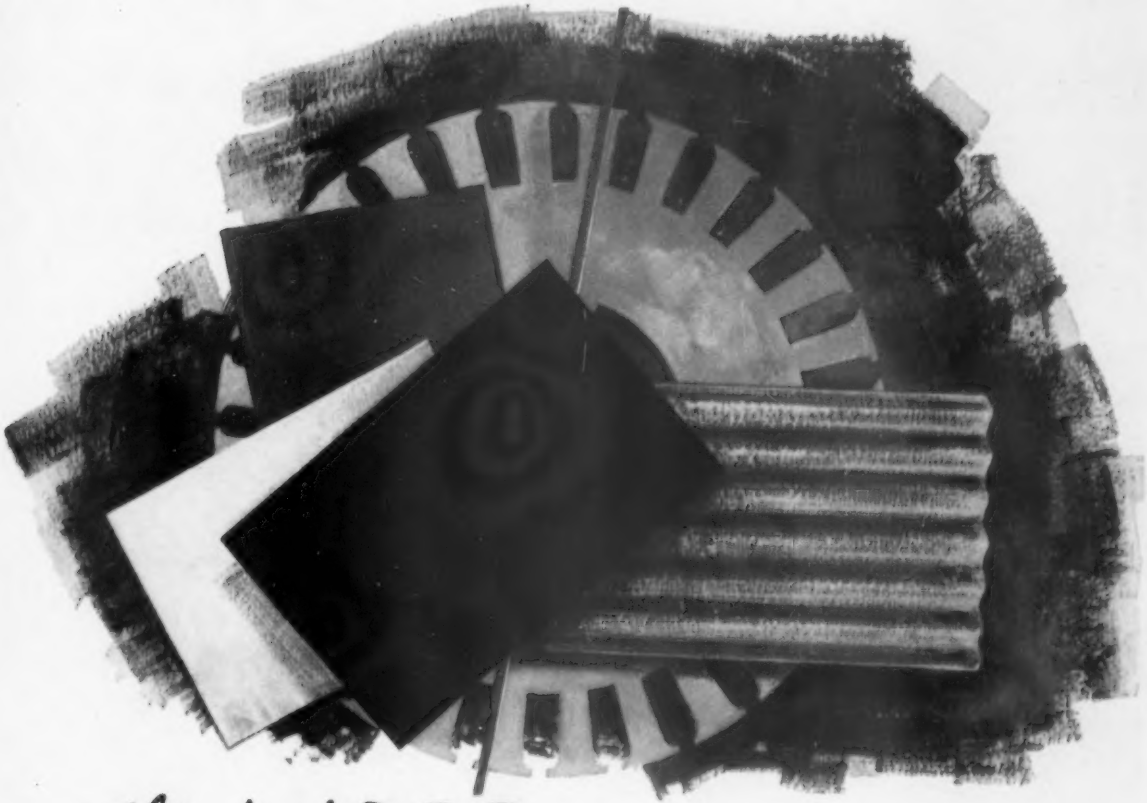
Established for over 50 years:-
There is no substitute for experience.

When you hear of NEW DEVELOPMENTS–



think of R·T·B

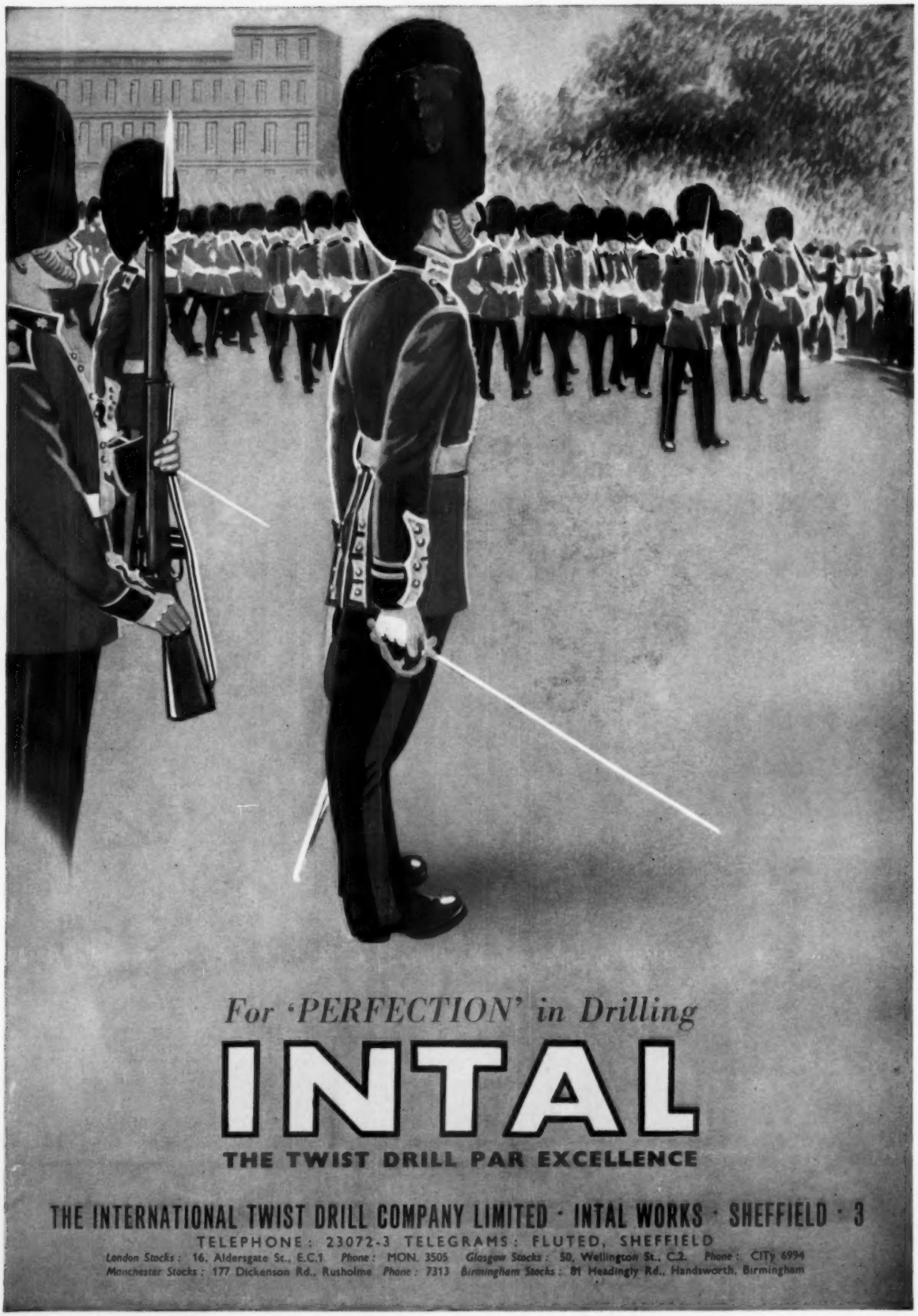
The illustration, with some latitude, serves as a reminder of R T B tinplate, black sheets and specially coated sheets—together with a corrugated 'Speltafast' galvanized sheet and, behind them all, a large electrical lamination, made by R T B from one of their special steels.

Our history comprises a long sequence of developments which have proved of far-reaching importance to industry and to the general public. In steel making, in the production of tinplate, sheet steel and strip, in the manufacture of special steels and laminations for the electrical industry, and specially coated sheets, the name of R T B has always been associated with leadership.

The latest R T B development is the installation of the largest continuous-galvanizing unit in this country—for the production of 'Speltafast' galvanized strip and sheets.

Richard Thomas & Baldwins Ltd.

R·T·B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LEY'S

Tested at 2,500 p.s.i.

The illustration shows a valve body for use in hydraulic control equipment. The complex nature of this valve body involves a great deal of machining; at the same time high mechanical strength is an important factor, since the valves are used at a high working pressure and are tested at 2,500 p.s.i.

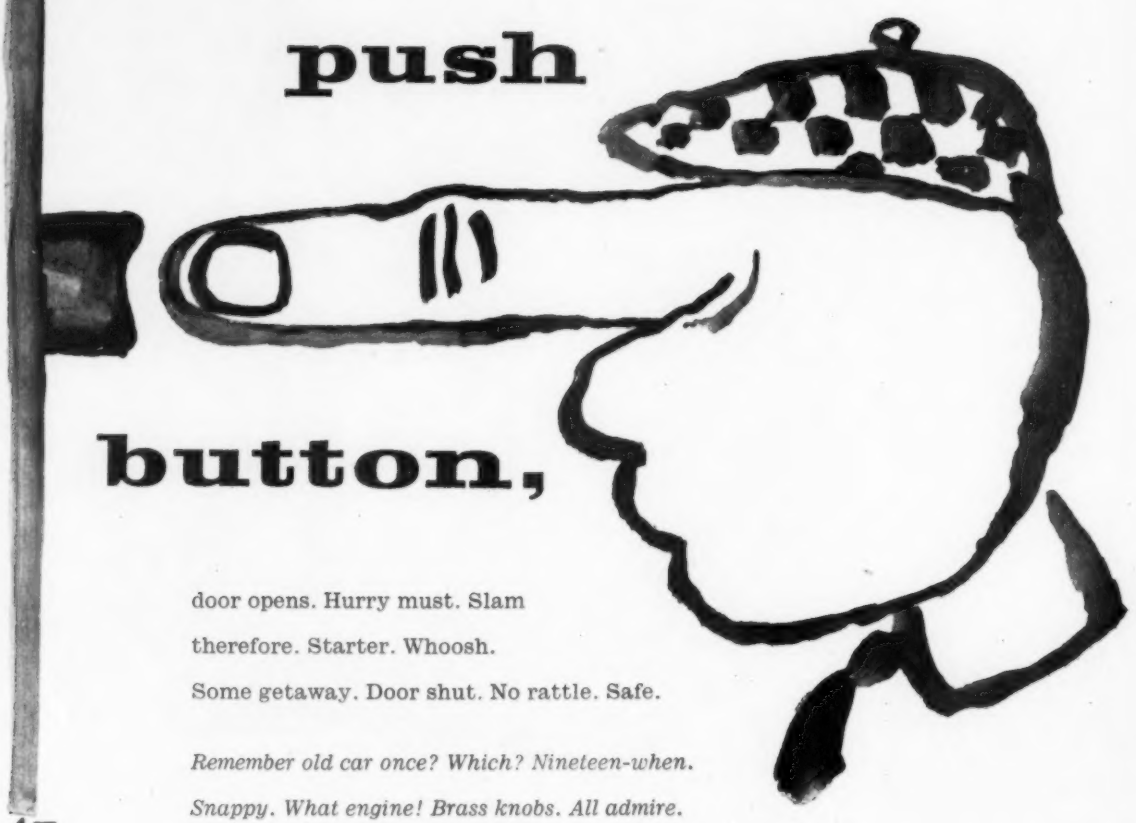
These considerations led to the choice of castings in 'Lepaz 35', a pearlitic malleable which combines excellent machinability with an ultimate stress of 33/38 tons sq. inch and an elongation of 6-8%.

LEY'S MALLEABLE CASTINGS CO. LTD., DERBY. TELEPHONE: DERBY 45671.

STRENGTH & RIGIDITY

LEY'S

You push button,



door opens. Hurry must. Slam
therefore. Starter. Whoosh.
Some getaway. Door shut. No rattle. Safe.

Remember old car once? Which? Nineteen-when.
Snappy. What engine! Brass knobs. All admire.
But locks, doors! . . . Rattle rattle. Squeak squeak click.
Rich aunt. Sharp corner. Door opens. Aunt on road. Undignified.
Doctor. Lawyer. Cut out of will. Unfortunate. Very.

Never again now. Wilmot Breeden make locks—rotary, cam-latching, Zero-Torque.
Make handles, push-buttons. For cars and. Safe safer safest. Last word.
Ingenious design. Ruthless testing. Constant progress. Onward and upward.

Likewise bumpers, window winders, boot-locks
and stays, steering wheels. *Virtually every British car roads today*
some Wilmot Breeden components. No wonder! Safe.

WILMOT BREEDEN are at Birmingham: *also at London, Manchester, Bridgwater, Glasgow, Melbourne, Toronto.*

VALVES BY FARNBOROUGH

Fitted as standard by the following British, American and Continental engine builders

ADMIRALTY
A E C
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ALLIS CHALMERS
BERGIUS
DAVID BROWN
CATERPILLAR TRACTOR
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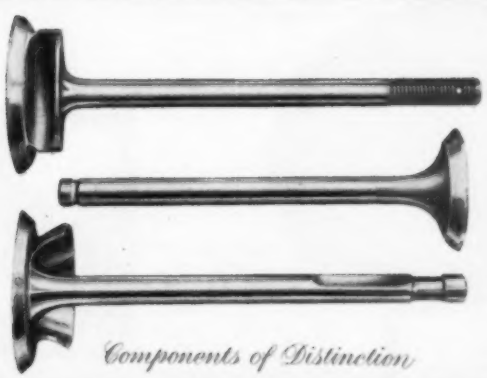
VOLVO



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FARNBOROUGH ENGINEERING CO LTD · FARNBOROUGH KENT · ENGLAND

Road and Rail

As suppliers of castings to the Motor Vehicle and Railway Industries, we produce vast quantities of castings in High Duty Iron from our fully mechanised plant.

The most modern methods of production, backed by a high degree of technical control, ensure that our castings meet with the exacting standards set by both these Industries.

DARCAST

DARTMOUTH AUTO CASTINGS LTD | SMETHWICK 40 STAFFS

AUTOMOBILE ENGINEER

CONTENTS

HOLLOW PARTS, PRODUCED WITHOUT THE USE OF CORES ON THE ROBAR DIE-CASTING MACHINE, CAN REDUCE DIE COSTS, METAL COSTS, PRODUCTION TIME AND COMPONENT WEIGHT

287 Editorial *Quality*

288 David Brown 557A Gearbox *Five-speed constant mesh gearbox with epicyclic reduction gear arranged to give ten progressive ratios*

295 Recent Publications *Brief reviews of current technical books*

297 Vehicle Dynamometer H. J. Eatwell, N. G. Bostock and J. R. Crowther *An automotive chassis dynamometer installation for fuel and lubricating oil research*

303 Crankshaft Turning *An American in-line transfer machine for crankpins*

305 Cromard Liners *Latest developments reduce cost of production and give technical advantages*

306 Interior Cooling for Cars A. S. Lamburn *Basic principles of air cooling for comfort, as applied to saloon car bodies*

308 Nuts and Bolts *Discussion of some of the factors affecting strength and fatigue resistance*

312 Fuel Consumption Measurement *Precision electronic apparatus for accuracy of recording consumption of small volumes of fuel*

314 Semi-Trailer Couplings H. C. Rippon *Arrangement designed to facilitate the operation of mixed fleets*

315 New Plant and Tools *Recent developments in production equipment*

316 Malleable Iron Castings *New foundry for Shotton Bros. Limited is arranged for continuous flow-line production*

321 The Hancock Telecontrol *An electromechanical, visual-record, control system to eliminate paper-work at all production supervisory levels*

324 The Robar Die-Casting Machine *Production of hollow components without the use of cores*

326 Current Patents *A review of recent automobile specifications*

Published the second Wednesday in every month
by ILIFFE & SONS LIMITED
Dorset House, Stamford Street, London, S.E.1
Telephone · Waterloo 3333 (60 lines)
Telegrams · Sliderule, Sedist London
The annual subscription inland and overseas is £3 0s 0d including the special number
Canada and U.S.A. $8.50

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Coventry · 8-10 Corporation Street
Telephone · Coventry 25210
Birmingham · King Edward House, New Street, 2
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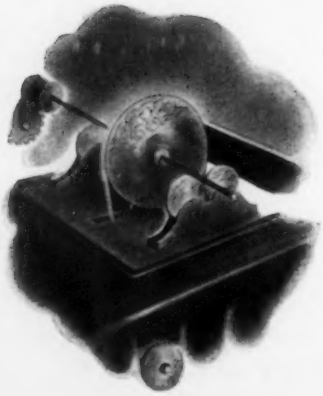
VOLUME 48 **NUMBER 8** **AUGUST 1958**

The Conquest of Friction



Instrument making flourished in the 18th century as scientific experiment became fashionable, and practical use was now made of several of the anti-friction devices first proposed by Leonardo da Vinci two centuries before. Henry Sully's chronometer (put forward in the competition for the prizes offered in 1714 by the Board of Longitude) employed such bearings, and Attwood in his 'machine' for demonstrating and measuring the acceleration due to gravity also successfully borrowed one of da Vinci's devices.

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DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Quality

A NEW conception of quality, its creation and control has been propounded in a report issued recently by a sub-committee of the Research Committee of the Institution of Production Engineers. It is gratifying to note that six of the nine members whose names are associated with the report are executives either in or closely connected with the motor industry. For this reason and also because of the importance of quality to this industry, particularly so far as exports to competitive markets are concerned, the work is worthy of careful study.

Attainment of quality involves first the formulation of suitable specifications, and then their realization. What is equally obvious is that these specifications must be such that the components of the vehicles to which they are applied not only can be produced economically, but also are adequate in respect of appearance, efficiency, interchangeability and life to ensure their success in world markets. Therefore, as all are aware, success can be achieved only by the co-operation of every department in each manufacturing organization, and its attainment in the greatest possible measure is a task beyond the capacity of the inspection department alone. In fact, attempts to improve quality simply by enforcing more stringent inspection measures tend to increase costs by hindering production, increasing scrap, and in some instances, by leading to deterioration in relations between operators and management.

The key theme in the new philosophy of quality control is the replacement of inspection after the event by positive action both prior to and during each production operation. This involves, principally, recreating the spirit of pride in the work, which has tended to be lost to some extent as the emphasis on quantity production has increased. This spirit is not so difficult to create as might at first be thought: most operators like to feel that the work they are turning out is of good quality, so it is only necessary to encourage the natural tendency for thinking on these lines and to avoid incentives that do no more than encourage quantity production without regard to quality. One type of incentive that can be applied is payment to the operator for a limited number of rejects, provided he finds them himself: if an inspector finds them, the operator is not paid for them.

Verification reliably and effectively carried out by the producer during or immediately after the operation eliminates the need for further inspection and enables corrective action to be undertaken immediately. Piece-by-piece inspection by the operator is practicable, and need not involve any increase in production time, provided suitable inspection equipment is introduced. This equipment should preferably be automatic and must be such that it can be speedily applied, its readings easily interpreted, and its accuracy maintained.

Operator control can be applied in several ways. One is by the introduction, on the machines, of instruments to indicate the dimensions of the workpieces as they are being produced, so that the machines can be stopped, tools changed, or the workpieces ejected, either automatically or by the operator when the correct dimension is attained. Inspection equipment installed adjacent to automatic and semi-automatic machines can be used for checking dimensions immediately after production of the component. This can be done while the machine produces the next component, so that the checking is carried out within the machine cycle time, and production capacity is not lost.

Where operations are such that a hundred per cent check is not practicable without extending the time cycle unduly, the operator can make a selective check. If the check is too complicated to be performed by the operator, it should be carried out by production department controlled checkers, as close as practicable to the machine or manufacturing process concerned.

With operator control, increases in production personnel, to cope with greater output, automatically provide for the increased checking necessary. It follows that, if the checking can be completed within the time cycle of the machines producing the components, the real cost of inspection becomes largely independent of the scale of production. There are many other advantages of this system. One is that the production and inspection departments work together with a common aim. Scrap and rectification are reduced, as also are inspection costs. It helps to relieve the monotony of repetitive operations and thus tends to reduce operator fatigue. Over the years, pride of workmanship will increase, and the improved quality of the product will benefit everyone concerned.

The adoption of this scheme of operator control can scarcely be successful unless the work of all departments in respect of this function is co-ordinated by a quality control department. The reason why the introduction of this new department becomes necessary is, of course, that it is essential for the organization of quality control to be carried out by personnel who are independent of design, production and inspection, so that they can effectively and without bias resolve the difficulties and differences of opinion that arise between all these departments.

DAVID BROWN

557A GEARBOX

Five-Speed Constant Mesh Gearbox with an Epicyclic Reduction Gear Arranged to Give Ten Progressive Ratios

So rapid has been the development of the commercial vehicle industry since the war that component suppliers have had to be constantly on the alert to keep pace with the interrelated developments in components other than those they manufacture themselves. In the heavy vehicle field the increase in the number of relatively small manufacturing concerns has been particularly marked. With their flexible production facilities these vehicle builders are admirably equipped to supply economically the demand for specialized and custom-built vehicles in modest numbers. Since they rely largely on proprietary engines, gearboxes, axles and other major components, it follows that the steady increase in power output from proprietary engines must be matched by an increased ability on the part of the transmission to handle the torque.

David Brown Automobile Gearbox Division has for many years catered for the varying demands of all kinds of vehicle producers, and the result is not only an impressive range of gearboxes in current production, but also a vast accumulation of experience in economical production of specialized types. The temptation to design a range of compromise parts that could be adapted to different sizes of gearbox is sternly resisted. In fact, the meticulous care with which each component is designed for its particular function is apparent, and if adaptation is resorted to it is only after most detailed study.

An interesting example of adaptation of existing components to the changing needs of the vehicle industry is the David Brown 557A gearbox, in which the existing five-speed constant-mesh gearbox is used in combination with the components of an existing two-speed epicyclic auxiliary reduction gear to form a compact and adaptable ten-speed gear unit. It should be explained that the first figure of the type number in the David Brown range of units indicates the number of speeds, and the two following figures indicate the nominal shaft centres, in this case 5·7 in. The suffix "A" denotes an auxiliary reduction gear.

The epicyclic auxiliary gear was originally designed as a separate unit for mounting amidships. On short wheelbase tractive units, it has proved to be difficult to use this arrangement, without incurring excessive angular displacement of the short sections of the divided propeller shaft. Apart from the provision of an adaptor casing and a modified gearbox mainshaft, very little alteration was necessary to the gearbox to enable the auxiliary gear to be mounted on its rear face.

The torque capacity of the original 557 gearbox, 350 lb-ft, was not sufficient for the larger engines now being fitted to the heaviest class of vehicle. It was found possible, however, to increase the width of the gear teeth without affecting the casing or other main parts, with the result that a torque of 480 lb-ft can now be handled. This enables the gearbox to be used with engines of the Gardner 8LW class.

In its separate form, the auxiliary gearbox could be mounted either way round to give reduction or overdrive, as required. When it is combined with the gearbox, the auxiliary gear is arranged to give a reduction. The gearbox itself can be arranged to provide either direct drive or overspeed on top gear.

All gears, including reverse, are in constant mesh. Changes are effected by sliding dog clutches, the design of which is such as to contribute to the compactness of the unit. The assembly is arranged with the change-speed mechanism at the side, so that a shaft can be taken forward to a remote control lever. Although the box is not completely reversible, only a slightly modified casing is necessary for conversion to right-hand or left-hand control.

Like the smaller synchromesh gearbox, the S550 unit, which was described in *Automobile Engineer* in April 1957, the 557 unit has a casing that is split on the plane of the axes of the mainshaft and layshaft. This design makes for ease of assembly, as the gears and shafts, with the selector mechanism, can be installed as complete sub-assemblies, in the bottom half of the casing. An added advantage is that assembly can be effected more satisfactorily when the gear trains can be seen easily, and therefore accurately aligned with a minimum of dismantling and re-assembly. As an aid to quick assembly, plastics shims are used; they are colour-coded for thickness. Being cheap, they are treated as expendable and can be easily cut for removal.

The compactness of the complete gearbox can be judged from the fact that the dimension between the front face and the rear end of the output shaft is 47 in, and the basic gearbox is 18¾ in long. Without the selector control tower, the unit is almost square in section, being 18 in wide at the widest part of the joint, and 17 in deep. The control tower

adds 7¾ in to the width. Complete with bellhousing and remote control lever assembly, the unit weighs approximately 600 lb. The bellhousings and primary shafts vary in size according to the engine for which they are designed.

A geometrical progression of ratios has been the aim in the design not only with regard to the gearbox itself, but also in respect of the intermediate steps provided by the auxiliary gear. How nearly this has been achieved is shown by the Table. It can be seen that, except in the case of the overspeed top gear, which is crossed by the auxiliary reduction, the progression is remarkably uniform. Since the object of providing ten ratios is maximum fuel economy, a great deal can depend on intelligent use of the gear lever by the driver. With these ratios at his command, he can either use the separate auxiliary change as a high or low range selector according to terrain and load conditions, or he can, by changing main and auxiliary gears alternately, keep the engine running almost constantly at its most economical speed. Since the relative speeds are low, the auxiliary change is extremely easy, and the physical effort required of the driver is small.

Aluminium alloy castings, of LM 4, B.S. 1490, are used for the main and auxiliary casings and for the bellhousing. Although recent legislation has rendered weight saving less important, the free machining properties and ease of handling of the light alloy, and the fact that its performance is entirely satisfactory, make the extra money spent on the material well worth while. All gears, the sliding dogs, and the primary and final output shafts are of En 36 steel, but En 39 is used for the more highly stressed mainshaft. The bearing housings are of En 2 mild steel, and the selector forks are of aluminium bronze AB2-C, B.S. 1400.

Whitworth hexagons and B.S.F. threads are used throughout, except where studs or setscrews are screwed into the aluminium casing, when Whitworth threads are employed. The company's policy with regard to changing over to Unified threads is to do so only when a completely new design is produced. Thus, the possibility of mixing threads in the same unit, with its attendant service difficulties, is avoided. In this case, the design of the basic components was well in hand before the change-over started to take place.

All gears in the main gearbox have single-helical teeth, with the exception of the reverse gears on the layshaft and reverse shaft which, in addition to their normal duty, provide the drive for the power take-off. The gears are cut on a Hydrax high-speed hobbing machine, made by the Machine Tool Division of the David Brown Group. Their teeth are shaved after hobbing. The annulus gear of the epicyclic train, and the dog teeth, which are integral with the single-helical gears but of much smaller diameter, are cut on Fellows gear shapers. On the sliding dogs, the internal teeth are broached.

After being machined, the gears are carburized in a Dow gas carburizing furnace, and hardened in a rotary hearth furnace. Then, after being quenched, the gears are tempered to a Rockwell hardness figure of C 61-63. The larger gears are die-quenched to control shrinkage and to avoid the necessity for finish-grinding.

Evidence of the great care that has been taken in the design of the gears is provided by the fact that the spiral angle of each train has been worked out to balance out the thrust according to the tooth loading in relation to the opposing train. An interesting feature of the profiles is that in each train a positive correction to give maximum strength is incorporated on both the gear and the pinion. Reference to the Table shows the relation of the numbers of teeth to the shaft centres, and the spiral angles of the different gear trains.

To suit the standard 16 in diameter driven plate of the clutch, the primary shaft has ten splines machined to the S.A.E. Standard, the diameter over the splines being 1⅛ in. The splines on the output shaft, and those on the rear end of the mainshaft, are parallel-sided, but involute splines are used for the sliding dogs and for the dog clutch hubs, where they are fitted to the mainshaft. To ensure ease of sliding, the splines on the dogs are bottom-fitting.

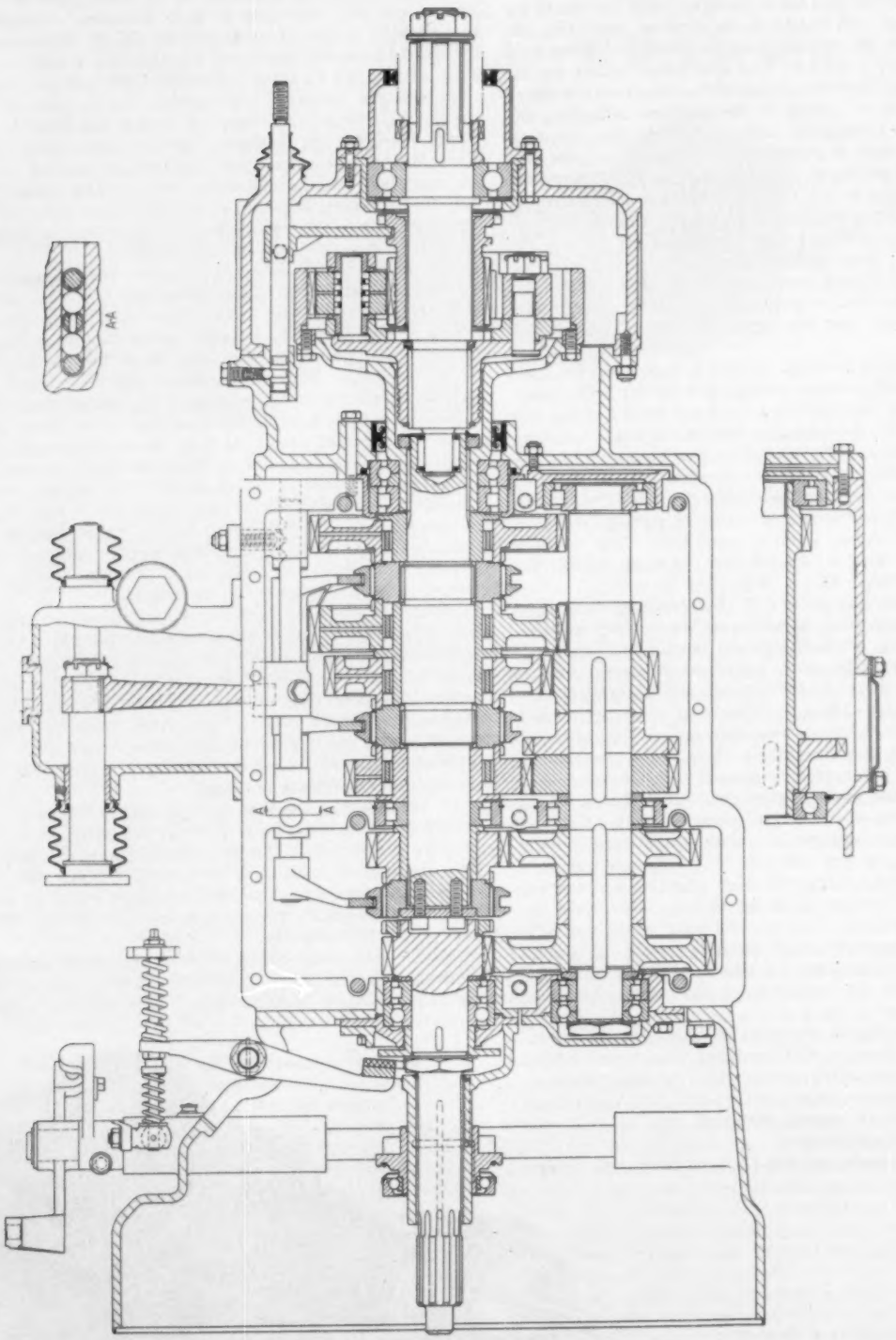
The axes of the mainshaft and layshaft are arranged in a horizontal plane. In one side of the bottom half of the casing is the reverse shaft, and in the other side is the selector mechanism. Two S.A.E. Standard power take-off apertures are provided, and the drive is taken from the spur gear on the reverse shaft. Both the mainshaft and the layshaft are additionally supported by bearings in the central transverse wall of the casing, between the third and fourth speed gear trains. An unusual feature is that, on the mainshaft, the fourth gear is overhung, there being no spigot bearing to support the front end of the mainshaft in the primary shaft. This has turned out be a most satisfactory way of supporting the mainshaft, since the provision of a spigot bearing of adequate size involved problems with regard to accommodation and, further, it was found to be difficult to ensure a constant supply of lubricant to the bearing.

Dowels are not used to locate the halves of the casing. Instead there are four ⅜ in fitted bolts and five ⅜ in studs in the side flanges. In addition, there is a ½ in bolt on each side of each of the three pairs of bearings, and three ½ in studs between the shafts. Special fitting of the joint faces has been found unnecessary, a coating of jointing compound being applied to the face-milled surfaces before assembly. The halves of the casing are, of course, bolted together for the machining of the bearing housings.

The bellhousing, supplied to suit each application, is spigoted on the bearing housing flange and attached to the casing by eleven bolts. These bolts, which have hexagon heads, are inserted from inside the casing, in which they are a tight fit. Clearance holes in the bellhousing ensure an easy fit in that component; this is important because the bolts cannot be held from inside.

A vertical split on the transverse plane divides the auxiliary gear casing, the rear half of which is the same as that for the separately mounted auxiliary unit. An adaptor casing

The gearbox casing is divided on the plane that contains the axes of the mainshaft and layshaft; thus, the sub-assembly comprising the gears, shafts and the selector mechanism can be installed complete in one operation during the manufacturing process



LAYOUT OF THE DAVID BROWN 557A GEARBOX

The epicyclic auxiliary box was originally designed for mounting separately in the transmission line between the main gearbox and the final drive unit

connects the auxiliary casing to the gearbox, being attached to its rear face by sixteen ⅜ in diameter setscrews. The rear casing is spigoted and flange-bolted to the adaptor by twelve ⅜ in diameter studs, the nuts being outside the adaptor flange. Machined faces, for power unit mounting brackets, are provided on each side of the rear casing.

To overcome the momentum of the relatively heavy moving parts of the gearbox and the driven plate of the clutch, a clutch stop of extremely simple form is provided. It is a swinging lever, padded at one end with friction lining material, which bears against a flange keyed to the primary shaft. The other end of the lever is connected by spring-loaded linkage to an idler lever on the clutch cross-shaft. This idler is actuated by the clutch lever, through an adjustable stop.

Since the primary shaft does not have to support the front end of the mainshaft, it has to react only the gear loads. It is carried by a combination of ball and parallel roller bearings mounted in a housing in the front wall of the gearbox, and is supported at its forward end by the clutch spigot bearing. The ball bearing, which is nearest to the clutch, is intended only for axial location of the shaft, and to take the thrust loads of the gear and clutch stop, so the periphery of its outer race is a clearance fit in the housing. Both bearings are retained in their housings by means of a cover. This cover, which is pulled tightly against the bearings, also acts as an oil retainer and has an oil return groove machined in its bore, where it fits over the hub of the clutch stop-flange. The cover, the bearing housing, and the sleeve that carries the clutch-withdrawal ball thrust bearing, are spigoted together and secured to the main casing by setscrews. On the shaft, the bearing inner races, together with a chip shield behind them, are pulled up against the clutch stop-flange by a thin nut locked by a tab washer.

Radial loads on the mainshaft are taken by parallel roller bearings. One of these bearings is retained directly in the centre wall of the main casing by a spring ring in a groove. The other, together with a duplex ball bearing that takes thrust loads only, is in a sleeve housing at the rear. Like the primary shaft bearing, it has a clearance round its outer periphery, but in this case, the inner race is split to allow a deeper groove construction.

Machined to four diameters and carrying four sets of splines, the mainshaft is so designed that, although the assembly is built up from both ends, it is nipped up by a nut at the rear end against a splined washer at the front end. This washer fits in a groove behind the first set of splines, with which it is turned out of phase. It is retained in this position by a parallel key, which, in turn, is kept in place by the sliding dog for the top and fourth gears. In addition it is a tap-in fit in its keyway, and is provided with a small tapped hole for a jack-screw.

The nut on the rear end of the mainshaft is an interesting example of a solution to a difficult problem of space-saving. Since the nut is deeply recessed inside the hub of the reduction gear input flange and, moreover, is screwed on to the end of the shaft that is bored out for a spigot bearing, none of the usual locking devices can be used. Therefore the nut is castellated on its outer periphery and locked as follows. A thin disc, with tabs formed over the central hole, is fixed in a recess in the outer face of the nut. The tabs are normally bent outwards, through 90 deg, but when the nut has been tightened, the tabs that happen to be in line with shallow radial slots in the end of the shaft are tapped down. For dismantling, the tabs can easily be lifted with a small chisel.

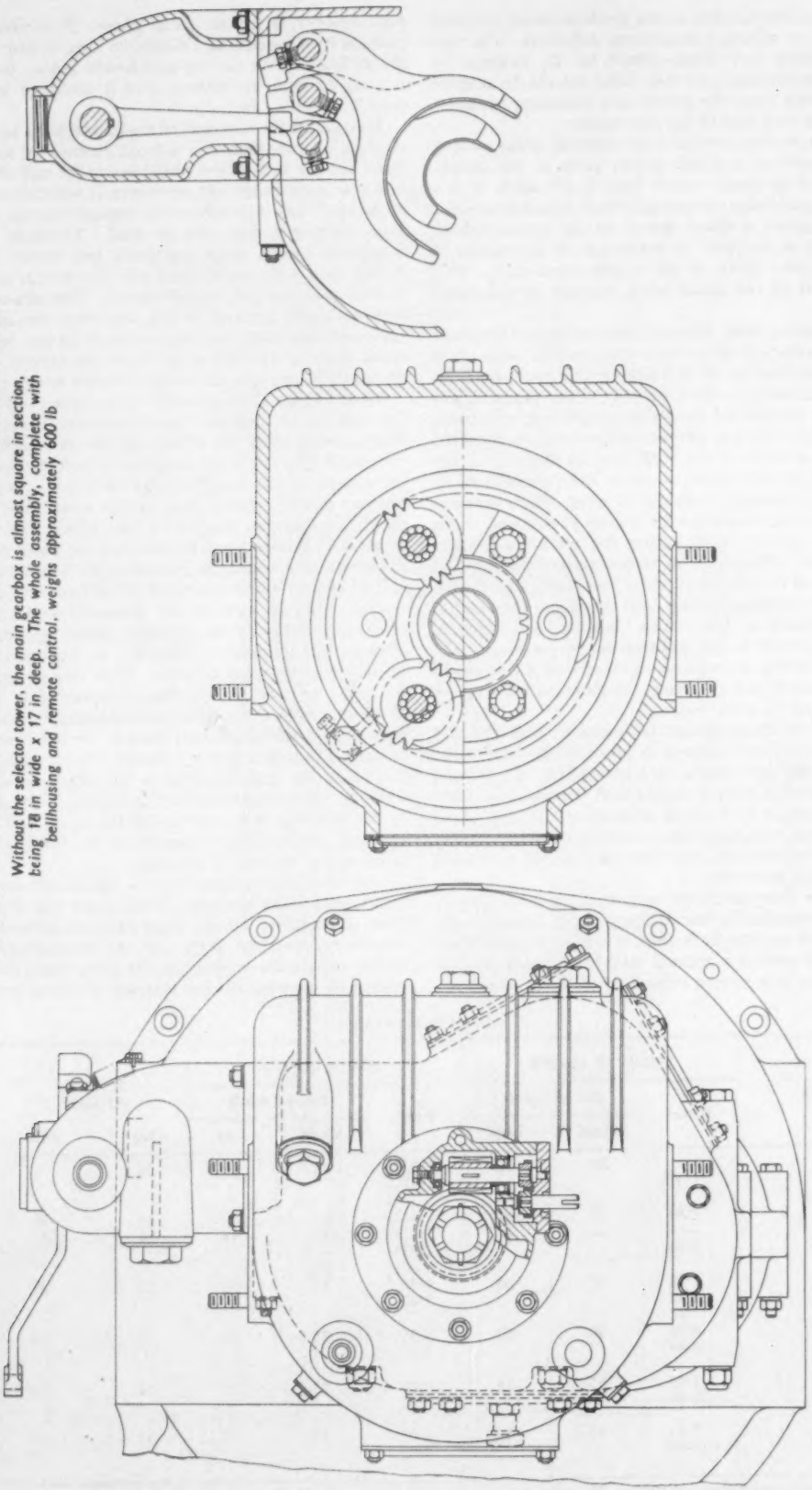
Modifications have recently been carried out to increase the tooth width, without involving alteration to the casing. These chiefly affect the sliding dog for top and fourth gears. Originally, this dog had external teeth on its forward end, and these engaged with internal teeth machined in the bored-out primary pinion. Had it been merely a matter of shortening the sliding dog, this could have been effected by the transfer of the fork-groove from the waist to the outer periphery of the internally toothed part, but then the length of the sliding splines relative to their diameter would have been dangerously reduced and, in view of the increased load capacity, the lengthened teeth of the primary pinion would have been inadequately supported. Instead, an enlarged hub, fixed to the shaft, has been adopted. With this arrangement, the internally toothed sliding dog, comparable in proportions to those used for the other gears, engages with a toothed ring splined to the primary pinion. It has been necessary to make this ring separate from the primary pinion because it is about the same diameter as the pinion, which therefore could not be hobbed with the ring in place. The cross section of the pinion is now solid under the teeth, and the washer retaining the mainshaft assembly at the front is secured by setscrews to the end of the shaft.

Five free-running gears on the mainshaft are carried on double-row roller bearings. The rollers run directly in the bores of the gears, but the inner races are formed by flanged sleeves fitted on the shaft. All the free-running gears are drilled radially for lubrication, the holes acting as centrifugal pumps by drawing oil mist through the roller bearings.

557A GEAR DATA

SPEED	DIRECT DRIVE			OVERSPEED			SPIRAL ANGLE		FACE WIDTH
	Ratio	No. of teeth		Ratio	No. of teeth				
		Main	Lay		Main	Lay	Deg	Min	In
Fifth	1·1	20	45	0·776	24	41	24	1	1¼
Fifth aux.	1·375			1·07					
Fourth	1·56	27	39	—	—	—	21	59	1¼
Fourth	—	—	—	1:1	20	44	27	57	1¼
Fourth aux.	2·14			1·375					
Third	2·78	37	30	1·76	34	33	19	46	1¼
Third aux.	3·82			2·42					
Second	4·70	46	22	3·35	45	23	17	16	1¼
Second aux.	6·45			4·61					
First	7·95	53	15	6·05	53	15	17	16	1¼
First aux.	10·90			8·32					
Reverse	7·95	53	15	6·05	53	15	17	16	1¼
Reverse aux.	10·90			8·32					

The normal pitch of all spiral gears is 0·500 in. The reverse spur gears have 31 teeth each, 6 diametral pitch, ¼ in wide.



GENERAL ARRANGEMENT OF THE GEARBOX CASING AND ITS SELECTOR MECHANISM

Without the selector tower, the main gearbox is almost square in section, being 18 in wide x 17 in deep. The whole assembly, complete with bellhousing and remote control, weighs approximately 600 lb

Three roller bearings take the radial loads from the layshaft, which is solid and formed integrally with the first gear pinion. The remaining gears are keyed on, and have distance-pieces between them. A duplex ball bearing at the front end takes the thrust. This bearing is similar to that at the rear of the mainshaft, both having a split inner race. The assembly of gears and bearings is pulled up on the shaft by a thin nut at the front end, locked with a tab washer. Both the front bearing housing and its cover are together retained by setscrews, but the housing for the rear bearing is covered by the closely fitting adaptor casing for the reduction gear. It is therefore held in place by grub-screws and locknuts inserted in the adaptor and pressing on the outer face of the housing. The flange of the housing has flats on its periphery to prevent it from rotating.

Driven from the layshaft by a 1 : 1 spur gear, the hollow reverse shaft is in constant mesh with the free-running gear on the mainshaft. Axial loading on the single-helical gear is not balanced out, but the thrust is taken by a substantial ball bearing, carried in the centre wall of the main casing. The rear end is carried by a roller bearing. Although serrations are machined in the bore at the rear end of the shaft, they are not used in this application, but are intended for a quill drive to a constantly running accessory such as a hydraulic pump or compressor, which can be used when the reduction gear is not fitted.

The three selector rods, mounted one above the other in the bottom half of the main casing, slide bodily, the selector forks and striking forks being located on them by setscrews. All the rods are notched at their rear ends to receive the ball-ended detent plungers which, with their springs, are retained in their drilled housings by a plate on the side of the casing. The interlock mechanism is orthodox, and comprises two large balls in a cross-hole in the centre wall of the casing. These balls are slightly larger in diameter than the distance between the peripheries of the rods. They register in shallow grooves round the rods. A plunger in a cross-drilling in the centre rod is equal in length to the diameter of the rod, less the depth of one groove. This arrangement ensures that only one rod at a time can depart from the neutral position. Distance-pieces form the stops for the selector rods. They limit the travel of the forks to slightly less than the maximum possible travel of the sliding dogs.

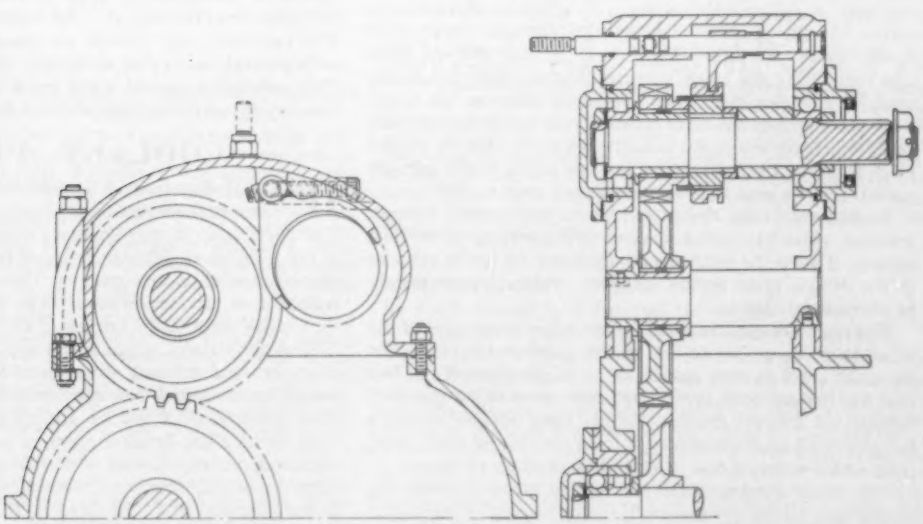
Remote control is provided for by the sliding and turning selector shaft which, with the striker lever keyed to it, is carried in a tower bolted to the side of the bottom half of the casing. A flange integral with the forward end of the shaft accommodates the universally jointed shaft that connects it to the remote control lever. A large filler plug on top of the selector tower is fitted with a dipstick.

Straight spur gears are used for the epicyclic reduction, because selection is effected by sliding the sun gear. The annulus gear is spigoted to a flange on the rear end of the mainshaft, and the planet pinion carrier is splined to the output shaft. Reduction is obtained by holding the sun gear stationary, and direct drive is engaged by locking the sun gear to the planet carrier.

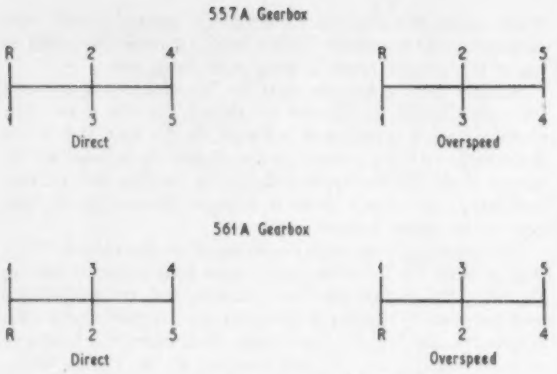
The planet pinion carrier is retained on the splines of the output shaft by a circlip and a split ring recessed into it. Its two parts enclose the three pinions, and are located and held together by three $\frac{3}{4}$ in diameter special fitted bolts, with castellated nuts locked by split pins. Four-row roller bearings, running directly on the spindles and in the pinion bores, carry the pinions. Flanged steel bushes carry the spindles in the halves of the carrier, their flange faces being hardened to take the small axial loads from the pinions. The hub of the carrier is quite a close clearance fit in the annulus hub, and has an oil return groove on it. This groove is arranged to pump oil towards the spigot bearing. To ensure equal loading of all three planet pinions, the sun gear is designed with a substantial clearance between it and the output shaft, so that it floats between the pinions.

Support for the front end of the output shaft is afforded by a roller spigot-bearing in the rear of the mainshaft. Its rear end is carried in a large ball bearing in a housing that also forms the locking member for the dogs on the sliding sun gear. This bearing housing, with the rear end cover spigoted to it, is bolted to a flange on the reduction gear casing. The rear end cover houses the speedometer drive, which embodies the usual spiral gears, the ratio of which is fixed, and a pair of spur gears, which can be changed to alter the ratio. A side cover gives easy access to these spur gears. Since the gearbox is intended for a wide variety of applications, with different final drive ratios, the facility for changing the speedometer drive ratio is important, and the replaceable pair of spur gears is an economical means of doing it. The spiral gear is keyed to the output shaft, and the shaft to which the pinion is keyed runs in ball bearings, the spur gear being overhung for ease of withdrawal.

Selection of the reduction gear is effected by a rod that projects through the rear of the casing and is protected by a rubber gaiter. The fork that registers in the sun gear groove is located on the rod by a setscrew. Three grooves are turned in the front end of the rod, and a spring-loaded



Straight spur gears are used in the epicyclic assembly, because selection is effected by sliding the sun gear on its shaft



Arrangement of the change-speed gates of the 557A and 561A gearboxes

ball in a cross-hole in the adaptor acts as a detent.

Although oil retention at the front end of the gearbox is effected simply by an oil return thread, precautions are taken at the rear to ensure that the oil in the gearbox remains separate from that in the reduction gear casing. An O-ring, recessed in the front face of the adaptor seals the joint, and two lip type oil seals are installed back-to-back round the rotating parts. At the rear end of the reduction gear, the output shaft—or rather the hub of the driving flange—is sealed by a double-lip type seal unit, which is designed to keep abrasive matter out, as well as to keep oil in. This has been found to be important in many of the overseas territories in which the gearboxes are expected to operate. The segregation of oil in the two parts of the unit avoids the danger of a lowering of the oil level at one end or the other of the unit on steep gradients, without resort to a complicated system of weirs. It also avoids the drilling of unnecessary transfer holes in an otherwise standard casing.

There are increasing numbers of vehicle applications, such as mobile cement mixers, heavy tippers and tankers for viscous fluids, in which a constantly available power take-off is called for, but where the power requirement is about 10 h.p., which is more than that allowed for by the S.A.E. Standard, regular side facing. This has brought about the development of a much more robust take-off, which will handle full power. Such a unit, having the same tooth width as the driving gears, has been evolved for the 557A gearbox. Its housing, carrying the power take-off shaft in ball and roller bearings, is mounted on top of a modified top half of the gearbox casing. In addition, this housing carries an idler spindle, on which the idler gear revolves on needle roller bearings. The pinion on the take-off shaft also runs on needle roller bearings, and is connected to the shaft by a sliding dog clutch similar to those on the main-shaft gears. Since the drive is taken from the largest layshaft gear, which on overspeed models is moved back to second place from the front, provision is made in the power take-off casing, for the gear train to be changed over to suit.

Basically the same design and layout are used for a larger gearbox, which has been developed to transmit up to 750 lb-ft torque. This is the 561A model, intended for use in vehicles in the 40-ton gross weight category, which operate mainly in overseas territories.

The auxiliary portion of this gearbox has an annulus of the same diameter as that on the smaller gearbox described, but the teeth are 2 in wide instead of 1¼ in. In view of the fact that the reverse shaft centres are such as to bring the shaft outside the annulus diameter, it has been possible to run a full power take-off straight back from the reverse shaft itself, thus avoiding losses due to an additional train of gears.

The drive is taken from the layshaft to a free-running cluster gear on the reverse shaft, the other gear of the cluster meshing with the free-running reverse gear on the mainshaft. A second pinion, running freely on the reverse shaft meshes with the free-running second gear on the mainshaft. This gear, of course, is continuously driven by the layshaft. A sliding dog clutch on the reverse shaft engages either the reverse cluster or the forward pinion. Thus the power take-off can be driven in either direction, regardless of whether the vehicle is stationary or in motion. Also reverse gear can be engaged without affecting the power take-off. The gears on the reverse shaft run on needle roller bearings.

To keep down the length of the reverse cluster, the mainshaft reverse gear and first gear have been transposed. Similarly second and third gears have been transposed to suit the forward drive pinion on the shaft for the reverse and power take-off gears. These changes are reflected in the arrangement of the change-speed gate shown in the diagram.

Since the power take-off output is designed for use when the gearbox is installed without the auxiliary portion, an extension shaft is fitted. This shaft drives through a dog coupling and is supported by a single ball bearing at the rear end of the auxiliary casing. On the larger gearbox, which is a more recent production, Unified threads are used throughout. The casing is of cast iron, and the weight of the complete gearbox unit, with bellhousing and control assembly, is quoted as approximately 1,036 lb.

BRITISH ENGINEERS' ASSOCIATION HANDBOOK

THE 1958 edition of the British Engineers' Association classified Handbook of members is a stoutly bound volume embodying nearly 700 pages. It includes a comprehensive list of members' products, classified under more than 3,000 product headings, arranged so as to be of maximum assistance to purchasers of engineering equipment. The classified index is repeated in French, German, Portuguese and Spanish. Also included in the Handbook is an index of trade names and marks. This book will be sent free of charge to selected buyers and agents in every country in the world that have business with the British engineering industry. The address of the British Engineers' Association is 32, Victoria Street, London, S.W.1

BOOKS

A COLLECTION of rare and current books on motoring and motor cars will be shown from the 22nd October to the end of November, 1958, by the National Book League, in its Stallybrass Galleries, at 7, Albemarle Street, London W.1. The exhibition will include models and prints, as well as early manuals and other early, and now rare, books on cars. This exhibition should show remarkably clearly how the industry appeared to those who saw its birth.

COOLANT PUMPS

BRITISH Standard, B.S. 2993:1958, for coolant pumps for internal combustion engines, has recently been issued. The application of this Standard should lead to a reduction in the number of different types of components used in the manufacture of coolant pumps. This, in turn, will lead to a reduction in production costs. The Standard covers pumps for internal combustion engines of up to 250 b.h.p.

This publication, which comprises 17 pages, specifies shaft diameters and housing dimensions for face type seals for centrifugal and axial flow type coolant pumps. It also gives some dimensions of suction and discharge stubs. All these dimensions were decided upon as a result of a review of existing practice. Copies of this Standard can be obtained from the British Standards Institution, Sales Branch, 2, Park Street, London W.1. Its price is 5s. plus postage.

Recent Publications

Brief Reviews of Current Technical Books

Hydraulic Handbook

Morden: THE TRADE AND TECHNICAL PRESS LTD., 1 Tudor Drive, Morden, Surrey. 1958. 10 × 7½. 664 pp. Price 90s.

The publishers claim that this is the first complete handbook ever to be produced on the subject of industrial hydraulics. It has been compiled by a team of authorities of high repute and embraces most of the available techniques and problems concerning industrial hydraulics.

An introductory section of over a hundred pages covers the principles of hydraulics. This is followed by a complete survey of hydraulic power equipment, including accumulators, actuators, electrical and hydraulic controls, cylinders and rams, filters, heat exchangers, hose and fittings, hydrokinetics, fluid couplings and converters, instruments, intensifiers, maintenance, manifolds, motors and transmissions, packings and seals, pipes and tubes, pumps, remote control, reservoirs and valves. The first section of the book ends with descriptions of the many and varied applications of hydraulic power in industry. This section is well illustrated with selected photographs and diagrams.

The 200 pages of technical data in the second section include 58 different circuits printed in colour. These have been compiled with the hydraulic designer's needs in mind. Many of the 125 tables, nomograms and charts are original, and have never been published before. Finally, a most useful and complete classified guide to manufacturers of hydraulic equipment in Great Britain is to be found in the third section, which should be of value to buyers and users of hydraulic equipment.

Metal Industry Handbook and Directory 1958

London: ILIFFE AND SONS LTD., Dorset House, Stamford Street, S.E.1. 1958. 8¼ × 6. 544 pp. Price 15s.

The *Metal Industry* Handbook and Directory is well known as a standard work of reference, and is a comprehensive source of information to all those engaged in, or connected with, the non-ferrous metal industries. Information on the properties of the newer as well as more familiar metals has been brought up to date, and the extensive section devoted to summaries of the Admiralty specifications and the British Standard Aircraft Materials, D.T.D. specifications, has again been included.

A wide range of producers, stockists and factors of all basic metal products, metal-working machinery and tools, and metal-finishing equipment is listed in the Directory for Buyers. The Handbook also includes a section on the chief metal-finishing processes and data regarding all the common rod, bar, sheet and strip products.

Extrusion of Plastics

By E. G. Fisher, Ph.C., F.P.I.

London: ILIFFE AND SONS LTD., Dorset House, Stamford Street, S.E.1. 1958. 8¼ × 5½. 118 pp. Price 21s.

In the immediate post-war years, The Plastics Institute published 24 monographs on plastics. These were for private circulation to members only. Recently, it was agreed to revise some of the original monographs and to produce a number of entirely new ones to cover the latest developments. At the same time, it was decided that it would be of benefit to the plastics industry if some of this new series enjoyed a wider circulation. Arrangements were therefore made with the present publishers, so that ten of the new series could also be made available for sale to the general public.

Each of these monographs is written by an expert in his own subject: the chemical monographs under the general editorship of Professor P. D. Ritchie, and the engineering ones under the general editorship of H. Barker. They have been planned primarily to cover the syllabus in the technology, chemistry, physics, and engineering of plastics, leading to the Diploma, Graduateship and Associateship of The Plastics Institute, but they will also be found invaluable by anyone who wishes to obtain specialized information on any subjects in the work.

This book on extrusion of plastics—one of the most important processes in the manufacture of plastics—is the first to be published under the new arrangement. It covers briefly all the phases of the extrusion of plastics, from both the practical and theoretical viewpoints; in addition, the more important features are treated in greater detail. Also dealt with are the various types of extrusion machines, constructional features, materials for extrusion, and the complete extrusion process. The contents are as follows: Introduction; Basic principles of extrusion; Theoretical considerations of the modern single-screw extrusion machine; Multi-screw extrusion machines; Constructional features of extrusion machines; Materials for extrusion and general applications; The complete process; and The extrusion of thermosets.

Sixth Symposium (International) on Combustion

London: CHAPMAN AND HALL LTD., 37 Essex Street, W.C.2. 1958. 10½ × 6¾. 943 pp. Price 224s.

Up-to-date developments in the combustion field, as presented by 216 contributors from ten countries, are recorded in this book. The work is, in fact, a full report on the Sixth International Combustion Symposium held at Yale University in August, 1956. There are 129 papers, providing an invaluable and stimulating source of new data and information on theoretical concepts and principles of engineering applications. Many aspects of combustion, including chemical, kinetic, aerodynamic and thermodynamic, are covered.

The subjects dealt with in these papers are as follows: Structure and propagation of laminar flames, 37 papers; Structure and propagation of turbulent flames, 6 papers; High-speed reactions, 8 papers; Flame stabilization in fast streams, 8 papers; Instability in combustion chambers, 4 papers; Ignition, 5 papers; Combustion of solid fuels, 8 papers; Combustion of explosives, and solid propellants, 11 papers; Evaporation and combustion of droplets and sprays, 10 papers; Experimental and analytical techniques in combustion, 9 papers; Applications of combustion, 20 papers. In addition to these papers, panel discussions are included on future problems concerning combustion research, high-speed reactions, and flame stabilization in fast streams.

Ford Cars

By T. B. D. Service.

London: C. ARTHUR PEARSON LTD., Tower House, Southampton Street, W.C.2. 1958. 7½ × 5. 242 pp. 10s 6d.

This book is one of the "Motor Car Maintenance and Repair" series, produced by this publisher. In it, the maintenance, general running adjustments and repair operations dealt with cover Ford cars produced at Dagenham from 1934 to the present time. In the first chapter the salient features of the three types of engine, that is, side valve, V-eight and overhead valve types, are outlined. Chapter 2 deals with lubrication, and general maintenance and adjustments. The succeeding chapters cover decarbonization, engine overhaul, cooling systems, clutch, gearbox, rear axle, fuel system, brakes, steering gear, front axle, and electrical system. Major overhaul, since it requires special tools and setting gauges, as well as a detailed knowledge of individual components, is not covered by the book. Nevertheless, for the benefit of owners who are interested in the construction and method of testing the major components, such as the engine, gearbox, and rear axle, these components are described in some detail.

Miles per Quart+

By J. M. Nuttall, A.F.Inst.Pet., M.S.A.E.

London: SCIENTIFIC PUBLICATIONS (GREAT BRITAIN), 3 Clifford Street, W.1. 1957. 7½ × 5. 87 pp. Price 8s. 6d.

This book is intended to inform motorists on lubrication matters. It discusses subjects such as which is the best oil to use, what the oil consumption should be, how often the oil should be changed, if a detergent oil should be used and, if so, should the various grades available be mixed indiscriminately. Most of the material in this book has appeared previously in *Scientific Lubrication*, but its presentation in this more permanent form was decided upon by the publishers because it is considered to be of great interest to the general motoring public.

A and B Roads Motoring Atlas of Great Britain

Edinburgh: W. AND A. K. JOHNSTON AND G. W. BAKER LTD., Easter Road. 1958. 13 × 10. 48 pp. Price 8s. 6d.

This atlas is particularly useful because the double-page spread represents from east to west a distance of 120 miles and from north to south 78 miles. So that it can be easily handled and stowed in a pocket or locker, it folds to half the single page width. It incorporates 42 simple street plans for important towns, generally either as insets on the page containing the map of the area that includes the towns, or on the preceding or following page. The scale is 6 miles to one inch; land relief is shown by graduated shades of green, and the A and B roads, with their Ministry of Transport numbers, are clearly represented.

Mechanical Vibrations

By Austin H. Church.
London: CHAPMAN AND HALL LTD., 37 Essex Street, W.C.2. 1958. 9½ × 6. 275 pp. Price 54s.

The author of this book is professor of mechanical engineering at New York University. His latest work is based on an earlier book entitled "Elementary Mechanical Vibrations," which was published by the Pitman Publishing Corporation. In the new book, the material has been almost completely rewritten to improve the method of development, and greater emphasis is laid on vector methods, the use of complex numbers and a more rigorous presentation. Also, the coverage has been greatly expanded to include such topics as forced vibrations of multi-mass systems, harmonic analysis, torsional critical speeds, electrical analogies, combined rotational and rectilinear vibrations, balancing of V-type engines, and so on. The number of problems included at the ends of the chapters has been more than doubled. In general, the work is based on courses given at New York University.

To understand the book, the reader should preferably have already had the normal engineering course in mechanics, strength of materials, and differential equations. It will be found that the text has been prepared in such a way as to give in a concise and orderly manner the principles of vibration analysis that may be used to deal with the problems that commonly arise and, at the same time, to lay the foundation for advanced work in this field. The author has felt that topics such as self-excited vibrations, non-linear systems, and damping in systems having more than 1 deg of freedom are beyond the scope of the work. Nevertheless, since balancing is intimately related to vibration, a chapter covering the basic principles of this subject has been included.

The chapters are as follows. In the introduction there are 15 pages, and it deals with definitions, simple harmonic motion, complex numbers and combinations of two simple harmonic motions. The next chapter deals with undamped free vibrations with a single degree of freedom. This is followed by another on damped free vibrations, also with a single degree of freedom. Forced vibrations with a single degree of freedom are dealt with in the fourth chapter. The section headed Two Degrees of Freedom covers pages 114-142. Multi-mass torsional systems are dealt with in 40 pages, and this subject is followed by a section on equivalent torsional systems, which are dealt with in 18 pages. The remainder of the book comprises three chapters entitled Multi-mass transverse systems; Balancing; and Electrical analogies. On this last subject, there are ten pages, and the book concludes with an alphabetical index.

The Autocar Road Tests 1958

London: ILIFFE AND SONS LTD., Dorset House, Stamford Street, S.E.1. 1958. 11⅞ × 8¼. 127 pp. Price 7s. 6d.

To give the most up-to-date information possible in book form at the start of the new buying season, the Autocar's annual Road Test Book is now being published in the spring, instead of towards the end of the year. In the 1958 volume, there are road test reports and complete performance data of 33 of the latest models produced in Great Britain, America and Europe. These reports include a description of the behaviour of each car under varying conditions; all the reports have been compiled after several hundreds of miles of testing in the hands of experts. In addition, comments are given on the construction and design of the cars, and detail plans illustrate the layouts of the controls, instruments and seating arrangements, all important dimensions being included. Among the illustrations are a large number of photographs, and at the end of the work there is a table summarizing data and performance figures. The table is useful in that it enables the principal figures extracted from each road test to be readily compared and also to be correlated.

Automobile Engine Overhaul

By A. W. Judge, A.R.C.Sc., Wh.Sc., A.M.I.Mech.E., M.S.A.E.
London: SIR ISAAC PITMAN AND SONS LTD., Pitman House, Kingsway, W.C.2. 1958. 7½ × 5. 234 pp. Price 15s.

The fourth edition of this book, which was originally published in 1938, has recently been prepared. It includes some new information and over fifty fresh illustrations relating to service overhaul, methods, tools and equipment. To incorporate the new material it has, of course, been necessary to delete some of the references and illustrations concerning a number of the earlier engines.

The new matter includes up-to-date information on cylinders, liners, pistons, rings, valves and crankshafts, servicing methods, tools and other equipment. In particular, the sections on main and big end bearings, lubrication and cooling systems, ignition and valve timing methods, have been largely rewritten and expanded.

W.O.

By W. O. Bentley.
London: THE HUTCHINSON GROUP, 178 Great Portland Street, W.1. 1958. 8¼ × 5½. 223 pp. Price 21s.

The initials W.O. will always be associated with fast cars and with that gay and uneasy period, the 1920's, when the products of his genius won race after race. W. O. Bentley is remembered not only for his racing and other types of car, but also for the Bentley rotary engines that helped to turn the tide of the war in the air in the First World War. His prowess on two wheels as well as on four also was impressive. The Lagondas of the 1930's and the engine that powers the Aston-Martin cars to-day were also designed by W. O. Bentley. This autobiography will undoubtedly be enjoyed by anyone interested in the struggles of a practical idealist who fought his way to success.

Advanced Pattern Making

By L. L. Cox.
London: THE TECHNICAL PRESS LTD., 1 Justice Walk, Chelsea, S.W.3. 1958. 10 × 7½. 222 pp. Price 45s.

One of the basic processes of the modern mass-production industry is the technique of repetitive casting in the foundry. Success in this technique depends on the production of patterns and core boxes that are not only dimensionally accurate, but also structurally strong enough and rigid enough for the manufacture of large numbers of perfect moulds and cores. Since new castings of ever more complex and exacting design are being called for as engines and machines develop in range and power, great demands will continue to be made on the skill of the pattern maker.

This new book has been written for the craftsmen of the industry and for apprentices who have already learned the fundamentals of their trade. Designers and draughtsmen will probably be interested in the pages dealing with pattern design itself and the sections on mould and pattern joints. Most of the subjects discussed are included in the syllabus for the final examination in pattern making set by the City and Guilds of London Institute. The author states that he hopes the more advanced level from which the book starts will make it of special use to those taking this examination or following similar courses elsewhere.

In this book the main emphasis is on the making of patterns in wood, but some attention has also been paid to pattern making in metal. With the increasing application of plate-moulding techniques and the growing use of core blowing machines, metal patterns and core boxes are becoming increasingly necessary to withstand the heavy usage to which pattern equipment is being subjected in large-scale production. Among the several recent developments in technique discussed in this book are the production and use of patterns and core boxes of plastics material. This is a technique that has only recently been developed to a satisfactory stage for application in general foundry work.

The chapter headings are as follows: Mould and pattern joints; Core prints; Pattern and casting design; Alternative methods of making patterns; Methods used for producing satisfactory castings; Patterns produced for opposite hand castings; Pattern equipment for producing small numbers of castings; Wheel and pulley patterns; Use of geometrical figures; Loam moulding; Use of metal on wooden patterns and core boxes; Gear wheels; Split wheels; Plaster work; Plate and machine moulding; Moulding machines; Machinery for the pattern shop; Layout of pattern shops; Metal pattern-making; and Setting-up methods and pattern checking. An index is included at the end of the work: this is most useful for reference purposes.

Vehicle Dynamometer

An Automotive Chassis Dynamometer Installation for Fuel and Lubricating Oil Research

H. J. Eatwell, M.B.E., A.M.I.Mech.E., N. G. Bostock, A.M.I.Mech.E., and J. R. Crowther

FUEL and lubricating oil developments usually take place in three stages, as follows: research on methods of manufacture, with the object of producing better products; preliminary proving in engines run on the test bed; and final proving by means of road tests, with a range of cars run under a variety of conditions to simulate the extremes that might be met in operation. As a result of many years of experience, well established test procedures have been developed for road testing in respect of the various aspects of the performance of motor fuels and lubricants. However, there are difficulties in carrying out comprehensive road tests in this country. One of these is that the special weather conditions required are either seldom met or do not persist over periods long enough for reasonable tests to be completed. Another is that it is becoming increasingly difficult to make these tests on the public highway, because of traffic congestion. This latter difficulty becomes critical as the performance of vehicles is raised.

The situation can be alleviated in two ways:

1. Provision of special proving grounds, such as the M.I.R.A. facilities at Nuneaton.
2. Provision of vehicle dynamometers suitable for the testing of vehicles under simulated road conditions.

The second of these alternatives is particularly attractive to the petroleum industry. This is because vehicle dynamometers have the additional advantage that if adequate provision is made in the initial design, atmospheric temperature and humidity can be controlled.

Design criteria

A vehicle dynamometer has been installed by The British Petroleum Co. Ltd., at their Research Station at Sunbury. It has been designed to deal with vehicles having engines with power outputs ranging from 28 b.h.p. and with fully laden weights of 1,700 lb, up to heavy vehicles powered by engines of 300 b.h.p. and with fully laden weights of 4,500 lb. For the heavier vehicles, inertia in excess of that due to 1,700 lb weight is simulated by electronically controlled dynamometers. Cooling air is blown over the car, the air speed increasing in direct relationship to the equivalent road speed of the vehicle on the dynamometer drums. Atmospheric temperature can be controlled automatically between the limits of the prevailing ambient temperature at the laboratory site and that likely to be experienced in the tropics: the maximum temperature attainable on the test rig is 120 deg F. There is a manual control to effect, at constant simulated road speed, limited changes in humidity above ambient conditions. The maximum test speed, attainable for limited periods, is 120 m.p.h., but for continuous operation it is 100 m.p.h. However, the speed of the cooling air flow is restricted to 80 m.p.h., so it is possible to operate a vehicle at, for example, 100 m.p.h., with air flow conditions equivalent to that same speed on the road when there is a 20 m.p.h. following wind.

The whole installation was designed so that a vehicle can be placed on the drums and prepared for test in the minimum possible time. An important factor in the design of the vehicle dynamometer and the building that houses it was the need to reduce the noise level outside the building to an absolute minimum, because of its proximity to laboratories used for fundamental research work and to private dwelling houses. In addition, standard components were employed as far as possible for the construction of the dynamometer machinery, so that material costs would be kept to a minimum.

In Fig. 1, the general arrangement of the equipment is shown. The rear wheels of the vehicle on test drive large steel traction drums installed on a trunnion-mounted, heavy-duty, two-speed axle originally designed for trucks. Standard universal couplings deliver the power through two eddy-current type dynamometers coupled in series to a second axle, which transmits the drive through a belt and pulley system to a centrifugal fan. With the exception of the dynamometer drums, all these key components of the dynamometer were available as standard items of equipment from the manufacturers concerned.

Another major feature in the design was the necessity to reduce the inherent inertia of the dynamometer system to a low level, so that acceleration tests could be made on the small European cars whose fully laden weight is as low as 1,700 lb. This feature had an over-riding influence on the choice of type and size of fan for the equipment. The

Table I. Inertia of the Vehicle Dynamometer System Expressed as Equivalent Car-Weights

Components	Moment of inertia I_F, lb-ft²	$x = \frac{\text{Component speed}}{\text{Drum speed}}$	Equivalent car-weight $\frac{I_F x^2}{r^2}$, lb
Two traction drums	8,462	1	1,355
Axle for traction drums	95·8	1	15·3
Axle for fan	22·0	1	4·4
Two high-speed couplings	2·0	6·3	12·5
Two Heenan and Froude dynamometers	6·9	6·3	88·0
Fan axle pulley	174·7	1	27·9
Fan rotor pulley	923·8	0·617	56·5
Fan rotor	175·0	0·617	107·0
High-speed shaft	0·69	6·3	4·4
			Total 1,671

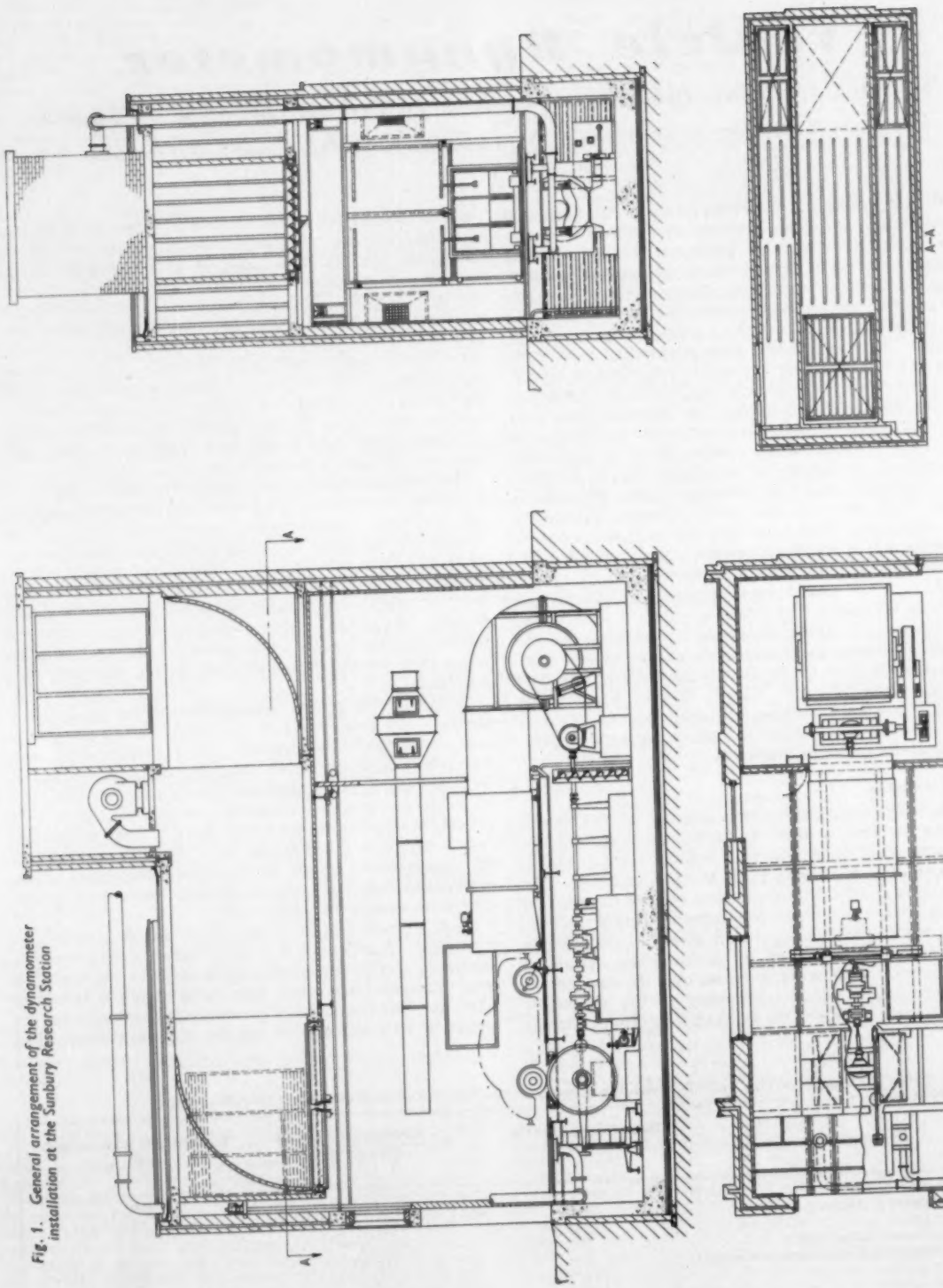


Fig. 1. General arrangement of the dynamometer installation at the Sunbury Research Station

function of this fan was firstly to supply adequate cooling air to the vehicle on test and secondly to match, as closely as possible, the wind resistance load of the test vehicle. In deciding the amount of cooling air to be provided by the fan, it was considered essential that the size of the duct should be such as to supply air flow over the full cross sectional area of the radiator grilles of the largest cars, so that during tests for vapour lock—one of the important functions of this equipment—the conditions could be expected to match those experienced on the open road. Adjustable flaps in the fan outlet duct enable the fan outlet area and the fan loading to be reduced for tests on smaller cars.

Mechanical design features

To meet the requirement for a minimum equivalent inertia of 1,700 lb, it was necessary to restrict the inertia of all rotating parts to the minimum practicable value. Calculations were, therefore, made to relate the inertia of each individual rotating component to the equivalent car weight at the drums, so that an assessment could be made of the total inertia of the system. A detailed assessment of the total inertia of the system as designed, expressed as equivalent car weights, is given in Table I. The figures were derived by the following method.

Let W = equivalent car weight, lb
I_p = inertia of the part under consideration, lb/ft²
V = velocity of the car, ft/sec
ω = rotational speed of the drums, rad/sec
r = radius of the drums, ft
X = ratio of the rotational speed of the part to that of the drums.

Then, for any component under consideration:

$$\frac{WV^2}{2g} = \frac{I_p(\omega X)^2}{2g}$$

But: $V = \omega r$

Therefore: $W\omega^2 r^2 = I_p \omega^2 X^2$

and $$W = \frac{I_p X^2}{r^2} \text{ lb}$$

It can be seen that the traction drums account for the major portion of the inertia of the dynamometer system. Two, 5 ft diameter × 1 ft 11 in wide, fabricated steel drums were designed. The dimensions, material and construction of these were a compromise in respect of the following requirements: minimum practicable inertia, consistent with adequate strength for the duty imposed; good conductivity, to dissipate the heat generated by friction between the vehicle road wheels and the drums; and large diameter, to reduce tyre deflection and thus maintain good tyre life. Each drum was fabricated by welding a ribbed, machined rim to two cones formed from ¼ in plate, as shown in Fig. 2. After final machining, they were statically balanced to within 2 lb at the rim. The two drum assemblies are bolted directly to the hubs of a heavy-duty axle, and will accommodate vehicles with tracks ranging from 2 ft 9 in to 6 ft 9 in. When fully loaded, the drums take a maximum bending stress of 3,200 lb/in², and the centrifugal stress at 100 m.p.h. is 2,300 lb/in².

The axle carrying the traction drums is an Eaton type 1350 Mk 11, heavy-duty unit, with a locked differential. Its driving ratios are 6·33:1 and 8·81:1. The standard Girling brakes fitted to the axle have been modified so that they can be applied pneumatically. For safety, the air supply to the brakes is taken through a solenoid-operated, three-way valve, electrically connected to the dynamometer circuit in such a way that when the equipment is shut down, the traction drums are held stationary.

A trunnion mounting carries the axle so that the power output of the vehicle on test can be measured at the road wheels. Both trunnion bearings are Cooper, 6 in diameter roller bearings of the medium series, with split races, and

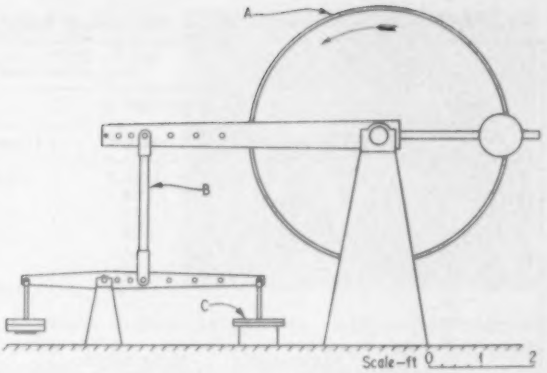


Fig. 3. The torque at the axle of the drum A is transmitted through a lever arm and a link B to a balance beam, one end of which is connected to an air-loaded diaphragm C, by means of which the torque loading is remotely indicated at the dynamometer control panel

fitted with turning gear to prevent local indentation of the races. The whole hub assembly is supported by a fabricated, steel gull-wing type mounting. An adjustable lever arm system is attached to the axle casing and this reacts on an air-loaded diaphragm, Fig. 3, by means of which the torque at the drum axle is indicated remotely at the control panel. The ranges of torques obtainable are from zero up to 366, 550, 880, 1,650, 2,605, or 4,690 lb-ft.

Two Heenan and Froude Mk 1 eddy-current dynamometers, each capable of absorbing 150 b.h.p. between 2,400 and 6,000 r.p.m., are used to simulate vehicle mass in excess of 1,700 lb, and also to simulate hill climbing conditions. The effect of the additional inertia is obtained by electronic control of the field current, to provide a torque component proportional to the acceleration of the system. Gradients are simulated by introducing the appropriate constant torque. These two components can be applied either together or independently.

An electric tachometer, driven by the dynamometer shaft, generates a voltage directly proportional to the vehicle speed, which is differentiated by an electronic circuit to give a signal proportional to acceleration. By means of a preselector on the control panel, the acceleration signal is multiplied by a factor corresponding to the weight of the test vehicle. A strain-gauge bridge, mounted on an arm

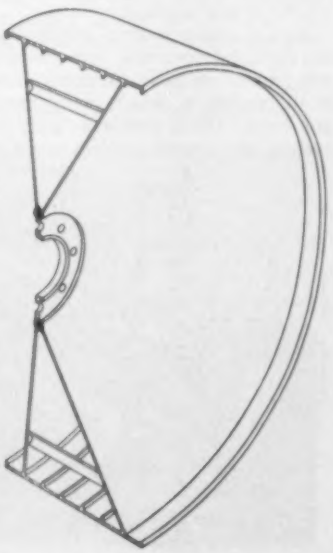


Fig. 2. Since the traction drums account for a major portion of the inertia of the dynamometer system, lightness was an important consideration in their design. After final machining, they were statically balanced in the usual manner

TABLE II. Comparison of Car Component Temperatures on the Road and on the Vehicle Dynamometer

Speed, m.p.h.	Car component temperature, deg C					
	Under-bonnet air		Water in head		Engine oil in sump	
	Dynamometer	Road	Dynamometer	Road	Dynamometer	Road
		Car B	Ambient temperature 16 deg C			
30	31·5	34	75	73	92	86
50	42	38	75	74	108	104
60	40	39	77	75	117	114
70	43	41	74	75	122	122
80	46	42	78	76	134	132
		Car D	Ambient temperature, 19 deg C			
30			70	72	73	78
40			73	76	79	85
50			74	78	88	92
60	Not available	Not available	75	77	95	100
70			76	75	104	107
80			77	75	112	115
90			79	78	120	124

attached to the eddy-current dynamometers, gives a signal proportional to the torque applied to the dynamometers. The multiplied acceleration signal is compared algebraically with the strain gauge signal, and the resultant voltage used to control the dynamometer field current and thus the applied torque.

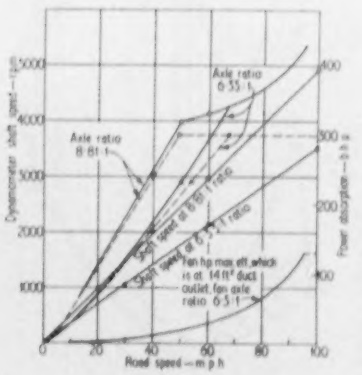
Other preselectors on the control panel enable the additional constant torque to be applied to the eddy-current dynamometers, to simulate rolling resistance and gradients. They can also be used to hold the vehicle at constant speed regardless of throttle position. The total power absorption curves for the dynamometer system are given in Fig. 4.

A 2 in diameter, high-speed shaft transmits the drive between the Dynamatic dynamometers and the fan axle. It is carried by four Cooper, special high-speed bearings mounted on standard pedestals. The bearings, which are fitted with thermocouples, are suitable for continuous operation at speeds up to 3,500 r.p.m., corresponding to 100 m.p.h. road speed, with the axles set at the 6·3:1 ratio.

The fan axle is of the same type as the drum axle, except that the hubs have been modified and non-standard brakes are fitted. One hub takes the fan drive pulley and the outboard bearing, which is of the Cooper 3½ in diameter medium series type, while the other can be used, if required, for providing a powered drive to the dynamometer system. The fan axle is rigidly fixed on a fabricated steel mounting similar to that of the drum axle.

Both the fan and drum axle mountings incorporate sumps for oil to lubricate and cool the axles. The crown wheels and pinions are oil-jet lubricated, and the oil gravitates back to the sumps, in which thermostatically controlled heaters are fitted. Oil is circulated from the sump through Serck coolers, and magnetic valves to the jets. Varley, type 501A pumps deliver the oil at the rate of 3 gal/min and 40 lb/in² pressure. The oil can be heated to 140 deg F before any test work begins, and is maintained at 140±9 deg F when the equipment is running.

The cooling water supply to the Heenan and Froude dynamometers is thermostatically controlled to maintain an outlet temperature of 120 deg F. It is discharged into a 375 gallon tank. This tank is fitted with a magnetic, level switch, which operates a pump with a throughput of 2,250 gal/hr against a 10 ft head.


Axle ratio 6·33:1
Axle ratio 8·81:1
Fan hp max eff. which is at 14 ft² duct outlet fan axle ratio 6·3:1
Road speed—m.p.h
Power absorption—h.p.

——— power absorbed by dynamometer and fan
— — — power absorbed by dynamometer

Fig. 4. Curves showing the total power absorption of the vehicle dynamometer with the two axle ratios

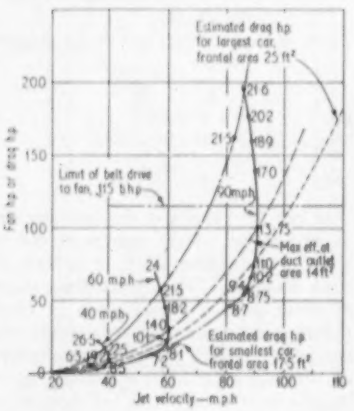

Estimated drag hp for largest car, frontal area 25 ft²
Limit of belt drive to fan, 315 b.h.p.
60 m.p.h.
40 m.p.h.
Max eff. at 14 ft² duct outlet area
Estimated drag hp for smallest car, frontal area 17·5 ft²
Fan hp or drag hp
Jet velocity—m.p.h.

Fig. 5. These curves of fan horsepower plotted against jet velocity are based on calculated values; they show how performance changes with variation in duct outlet area, neglecting duct losses. The spot figures indicate fan outlet area square ft

Since the windage losses of a vehicle are approximately proportional to the cube of the road speed, the equivalent horse power can be absorbed by a suitable fan. In the installation, an Airscrew and Jicwood, double-inlet, 60 in diameter centrifugal fan is used to simulate the drag horse power and supply cooling air to the test car. The fan drive is directly connected to the dynamometer drums, so the speed of the air increases approximately in direct relationship to the equivalent road speed.

This fan is capable of absorbing up to 120 h.p. while delivering 130,000 ft³/min of air at 8 in standard water gauge pressure. The fan outlet duct was designed as a telescopic unit, mounted on castors, to allow for a full range of different size cars to be tested. It is fitted with three adjustable louvres for varying the fan load. The two outside louvres are preset, but the centre one is motor-actuated to permit final adjustment from the control panel. In Fig. 5, jet velocity is plotted against fan horse power, to show how fan performance varies with duct outlet area. It can be seen that the maximum estimated wind load for the largest car at 90 m.p.h. can be

simulated with a duct area of 11 ft²: this is well within the maximum power rating of the fan. To minimise the inertia, the fan rotor is of aluminium.

A front wheel chocking device locates the car on the dynamometer drums. The wheels are pulled on to chock plates by small worm drive winches on a slotted bar positioned transversely in front of the vehicle, Fig. 6. This bar is in turn fitted to two T-slotted runners mounted longitudinally in the base plate, Fig. 7, thus providing for adjustment to suit different track and wheelbase dimensions. Experience has shown that, with this arrangement, the car is stable under all driving conditions: there is no bumping when either the throttle opening is changed or the engine misfires.

The car exhaust is connected by flexible tubing to one of two open-ended pipes just below the floor level, behind the traction drums, so that exhaust contamination of the air in the test cubicle is avoided. Both pipes are joined to a common manifold, which is ducted to a Keith Blackman fan capable of extracting 2,600 ft³/min. This gives a gas velocity of 110 ft/sec at the open ends of the pipes.

To meet the variable temperature requirements, for simulating temperate and tropical climates, two fans of a total capacity of 5,000 ft³/min draw air from the rear of the test cubicle, pass it through steam heat exchangers and discharge it into the fan chamber below the inlet louvres. A system of electrically actuated mechanical links control the inlet, outlet and circulation louvres and, in conjunction with the electric motor actuated steam valve on the heat exchangers, regulates the temperature between ambient and 120 deg F. The closure of the inlet louvres is restricted by a stop to ensure that under all conditions adequate air is passed for combustion in the engine of the car on test. By metering water through jets below the inlet louvres, humidity in the test cubicle can be controlled to a limited extent under constant speed conditions. The temperature and humidity conditions can be set at the control panel, but the control mechanism is situated in the fan outlet duct.

Instrumentation

The control panel shown in Fig. 8 incorporates all the instruments that indicate the operating conditions of the test car, and all the operating controls and safety device indicators. Among the instruments for indicating operating conditions for the test car are recorders for temperature surveys, and indicators for engine r.p.m., car and air speed, ignition spark advance angle, total dynamometer load, engine oil pressure and a total mileage. The controls include a throttle lever, a manually operated ignition advance

Fig. 6. The chocking system used at the front wheels of the vehicle on test

and retard, cubicle temperature control, dynamometer controls for the simulation of car inertia and hill climb conditions, and all the pump and motor switches.

Safety devices are incorporated for the protection of both operating personnel and the machinery. Among the devices for personnel safety is a two-way intercommunication system between the control panel and the car, with loudspeakers and hand microphones in each place. A continuous sampling, carbon monoxide alarm is fitted in the test cubicle: should the carbon monoxide concentration reach 0·01 per cent, audible warning is given and warning notices light up in the cubicle and at the control panel.

It is impossible to start any test work until all the motors driving the circulating pumps and fans are running, and lights mounted on the panel indicate which equipment is running and which is shut down. In addition, if the pressure in either the axle lubrication system or the cooling water supply to the plant drops to 5 lb/in², pressure switches activate alarm lights and a bell. A high-level switch in the discharge tank operates the alarm system if the water rises to a dangerous level. The thermocouples fitted to each of the bearings of the high-speed shaft operate an alarm system if the bearing temperatures reach 80 deg C.

Performance data and general comments

The dynamometer has been fully commissioned and has run an equivalent of 36,000 road miles under a variety of test conditions. Minor development troubles, associated with vibration at high speeds were experienced; they affected adversely the operation of the strain-gauges on the dynamometer. Modifications have been made to obviate these difficulties, and commissioning tests and subsequent operation of the dynamometer have shown that road performance is satisfactorily reproduced. From Fig. 9, which illustrates the results of acceleration tests obtained on three cars, the ability of the dynamometer to reproduce the level road

Fig. 7. This illustration shows a car being motored on the rolls

Fig. 8. All instruments and controls are mounted on one panel

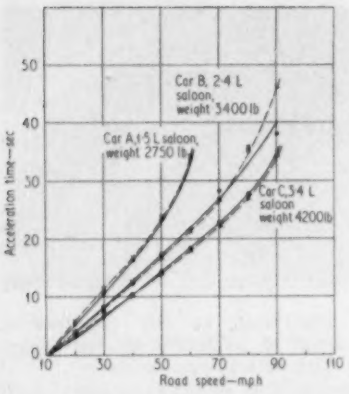


Fig. 9. Comparison between acceleration times, at full throttle in top gear, on the road and on the vehicle dynamometer

— — x — — *road tests*
——●—— *vehicle dynamometer tests*

acceleration performance of the cars is apparent. The operating temperatures obtained in two cars both on the road and on the dynamometer at various speeds are shown in Table II.

This installation is particularly suitable for meeting the requirements for testing petroleum products in automotive equipment. In particular, some of the routine tests that can be speeded up and improved in accuracy by the use of this equipment are: octane requirement determination, anti-knock rating of motor gasolines, vapour tolerance of vehicles and the vapour locking tendency of gasolines. Many other investigations of a more fundamental nature will be facilitated by the employment of this dynamometer, and its usefulness in evaluating the performance of complete vehicles operated with different fuels and lubricating oils is considerable. The intensive development of motor fuels and lubricating oils that has already taken place in recent years has been of great assistance in the development of engines of greater efficiency. This development will continue, with close co-operation between the petroleum and automobile industries, to the benefit of the motoring public.

The authors wish to thank the Chairman of The British Petroleum Co. Ltd., for permission to publish this information and also to thank their many friends and colleagues, both in this country and in the United States of America, who, when the dynamometer was in its early design stage, gave freely advice based on their experience of the operation of this type of equipment for a wide range of applications.

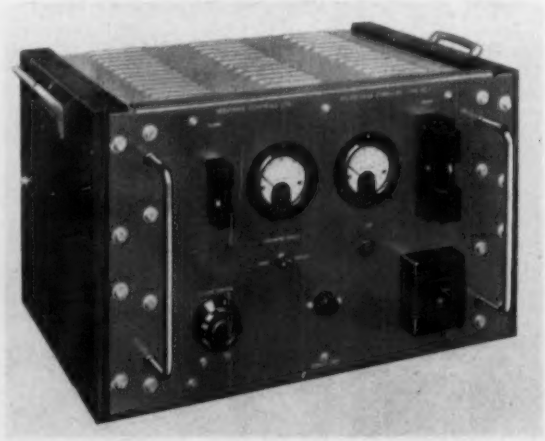
Voltage Stabilizers

An Instrument for Regulating the Electrical Supply, to Ensure Accurate Operation of Electric and Electronic Equipment

IN certain areas, heavy concentration of industry frequently causes overloading of the electrical supply system, and this results in variations in the voltage of the supply. Therefore, a voltage stabilizer is necessary to ensure the accurate operation, in all circumstances, of delicate electrical equipment used in many laboratories. The equipment for which stabilizers are required includes measuring and controlling units and, especially, electronic apparatus.

To meet the increasing demands for a dependable yet economical voltage control unit, Servomex Controls Ltd., who are specialists in the manufacture of electrical control instruments, have produced a range of voltage stabilizers of the electro-mechanical type, which, while giving a speedy time of response, are very economical as regards both outlay and cost of operation. Their type AC7 unit, for instance, will stabilize, with an accuracy of $\pm 0{\cdot}25$ per cent, a variation of input voltage from -20 per cent to $+10$ per cent, with a load current from zero to 30 amp and a frequency from 45 to 65 c/sec. The response time for small errors is from 0·25 sec, while large errors are corrected at the rate of 12 volts per second. Once set, the r.m.s. value of the output voltage is maintained constant throughout the year, irrespective of fluctuations from zero to 30 amp in the load current and of variations in the type of load power factor. The wave form is not distorted; moreover, the accuracy of the instrument is unaffected by changes in temperature of as much as 20 deg C.

The type AC 7 voltage stabilizer for regulating A.C. mains input to ensure the accurate operation of delicate electrical equipment



In principle, the unit functions as follows. The output is applied to a bolometer bridge, from which the output is zero when the voltage is correct. If the voltage varies from the set value, the bridge output increases and, after amplification, drives a two-phase servo-motor, which restores it to the correct value. Velocity feed-back is used to provide stability and to make the instrument independent of friction. Model AC7 contains only two valves and has not any relays, thyratrons or electrolytic capacitors in any part of its circuit.

These instruments can also be used as a variable voltage source: they can be set to give an output within about one volt of any required value near the nominal voltage of the supply. To a certain extent, the output voltage can be varied within ± 10 volts by means of a knob on the front of the instrument, and within a wider range by altering an easily accessible six-way voltage selector plug at the back. A special feature of these instruments is that they are unaffected by vibration and will withstand accelerations of up to 40 g in any direction. Further details can be obtained from the manufacturers, who's premises are situated at Crowborough Hill, Jarvis Brook, Sussex, England.

CRANKSHAFT TURNING

An American In-Line Transfer Machine for Crankpins

IT is generally recognized that the machining of crankshafts is one of the toughest cutting jobs in the automobile industry. Now, however, as a result of an eight-year research effort by the Machine Tool Division of the Wickes Corporation, Saginaw, Michigan, U.S.A., a new concept has been devised for machining the crankpin diameters of forged-steel crankshafts. It is claimed to have the following advantages.

1. Carbide cutting tools can be used
2. Production can be doubled in about the same, or slightly less, floor space than hitherto
3. Re-tooling costs to meet design changes are practically eliminated
4. Direct labour costs are reduced
5. Cutting tool costs are reduced by almost 50 per cent
6. Capital investment for machines to produce a given output is reduced
7. Crankshafts to several different specifications can be machined on a single line.

The method developed by the Wickes Corporation consists in coupling together, in line, a number of single-purpose lathes of simple design. Each of these lathes is fed from a common automatic line arranged parallel with the machine line. The whole set-up is designed for sequentially machining the four crankpins of a forged steel, four-throw crankshaft for a vee-eight automobile engine.

Previously, crankpin turning involved the use of two different machines, one for roughing and one for finishing. The net production from each machine was 22-25 shafts per hour. Special high-speed steel form tools were used. Any change in the crankshaft specification called for extensive re-tooling, which took about one month and was extremely costly.

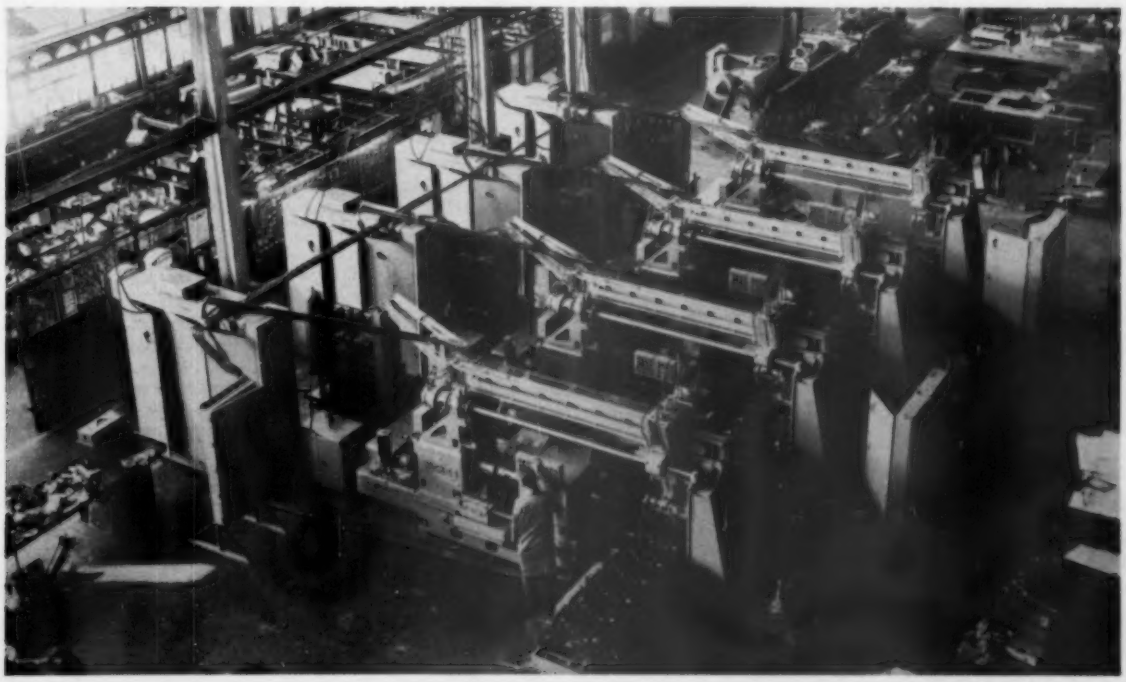
At best, not more than 40 crankshafts could be turned between tool regrinds. The monthly bill for cutting tools amounted to 20,000 dollars for an output of 150 crankshafts per hour. Furthermore, tool-changing time ranged from 45 minutes to 1½ hours per machine, since each change involved 16 to 24 cutting tools per machine.

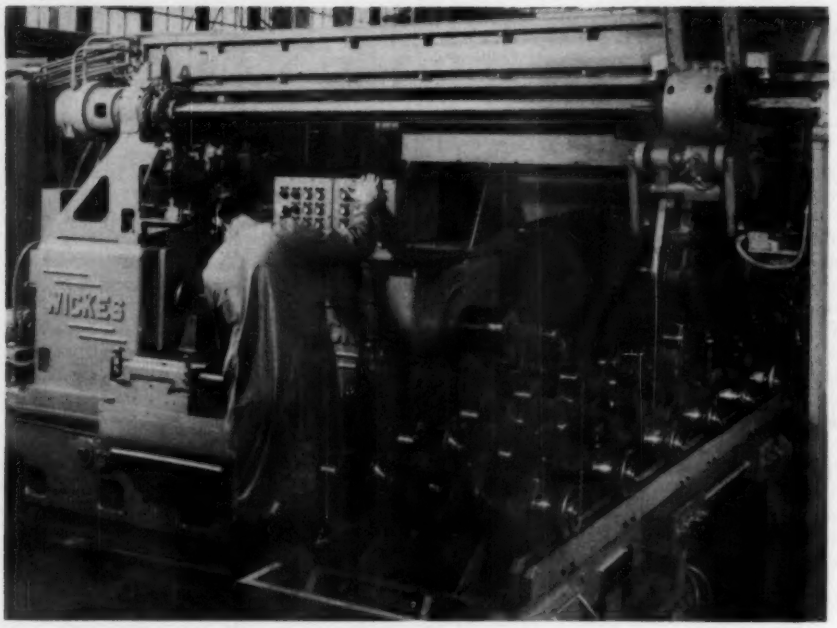
The new Wickes development shows considerable savings. In the first place, tool changing on any one of the four lathes takes only five minutes, because standard carbide-insert cutting tools are used and only one pin is turned at each station. In addition, the set-up is such that while one machine is down for tool changing work continues to be fed automatically to the other three lathes.

Because cemented carbide tools are used, it has been possible to step up the machine speeds from 60 ft/min to 250 ft/min. As a result, the output from each four-station machine is 50 crankshafts per hour. Although the first cost of cemented carbide tools is higher than that of high-speed steel cutting tools, total tool costs are reduced by more than one half because of the longer runs between regrinds. Experience has shown that a minimum of 80 shafts can be turned before the tools need to be changed.

Each of the four lathes is powered by a 60 h.p. D.C. variable-speed motor, which gives a 3:1 speed range for

General view of Wickes four-station, automatic transfer machine for turning the pins of four-throw crankshafts





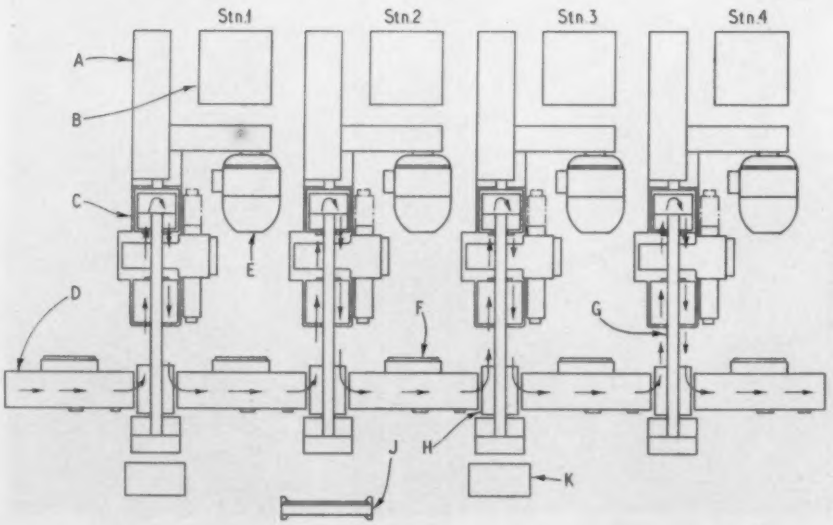
First-station lathe at the loading end of the transfer machine

facing the webs and plunge-cutting the pin diameters. Each machine cycle is fully automatic. The crankshafts are loaded on the first section of the conveyor and are automatically moved forward to the first machine until the line serving that machine is fully loaded.

When a crankshaft arrives opposite the first machine, a cross slide, travelling at right angles to the conveyor, picks up the shaft, reverses, and carries the work about 5 ft and places it in the open jaws of the machine chucks. The jaws are then closed automatically and the cutting tools are brought into action, also automatically. In less than one minute the No. 1 pin is finish turned. A second slide then goes into action. This unit picks up the work when the chuck jaws open and carries it to the in-line transfer device which then carries the shaft to the next lathe station. The movements to the next three stations are identical, except that on each a different pin is machined. The chucking in each succeeding station is, of course, arranged to compensate for the different position of the pin being machined.

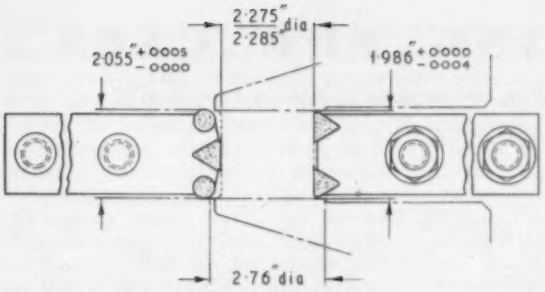
Every station of the line can be operated either automatically, independently or manually to provide flexibility in tool-changing or in production. The work cycle of each station is set so that each time an operation is completed and a shaft is unloaded, another takes its place. The total capacity of the automatic transfer line is 32 crankshafts, 8 before each station.

In case of a tool change on one of the stations, the automatic line is so set that as a crankshaft is released from a restarted station, it is automatically transferred to the vacant position nearest the next lathe. The automatic conveyor repeats this process until the whole line between stations is again loaded to capacity. Thus, any gaps on the transfer line are rapidly eliminated and lathes are not idled for lack of work.



A *control cabinet;* **B** *hydraulic unit;* **C** *single-spindle lathe;* **D** *loading station;* **E** *60 h.p. motor;* **F** *control panel;* **G** *overhead slide rail;* **H** *transfer mechanism;* **J** *control cabinet (automation);* **K** *hydraulic unit (automation)*

Diagrammatic layout of new Wickes automatic, in-line, four-station transfer machine for turning forged steel crankshaft pins



Sketch showing arrangement of standard triangular and circular carbide inserts on the cutting tools. The work is machined from front and rear simultaneously to cheek and turn the pin diameter in one operation

Each machine in the line is a double-end drive unit. Feeds are controlled by opposed cross-slides for straight plunging or in-feed. The slides are actuated by means of a hydraulic cylinder through a cam bar. An interesting feature is that the cam bar operates the slides through shoes, instead of the more common rollers, to support better the thrust of the cutting tool and to provide more rigidity. The chucks, like the cross slides, are controlled hydraulically.

The carbide cutting tools at each station approach the work from both the front and the rear. As shown in an accompanying sketch, two circular inserts are used in the front tool for the cheeking operation, and a triangular-shaped insert for plunge cutting the pin diameter. The two triangular inserts in the rear tool are arranged to plunge and complete the pin diameter and the corner radii. The round inserts are mounted at an angle to provide a negative rake, while the triangular inserts are given either a zero or slightly positive rake.

The feed for plunge cutting the 2 in wide pin is held to about 0·010 in. For cheeking, which involves an interrupted cut, the feeds are from 0·040 in to 0·060 in. The total depths of cuts average about 0·25 in and cutting speeds are approximately 250 ft/min.

Cromard Liners

Latest Developments Reduce Cost of Production and Give Technical Advantages

CHROMIUM plated liners made from mild steel tube are well known for their exceptionally good wear-resistance. Engine life of well over 250,000 miles between rebores is commonly experienced with these liners, which were described in an article entitled 'Cylinder Liner Design', published in the October 1953 issue of *Automobile Engineer*. The manufacturers, Laystall Engineering Co. Ltd., of 53, Great Suffolk Street, London S.E.1, have recently made further advances in the production of these components. As a result of these advances, the prices can be reduced and certain technical advantages gained.

These latest Cromard liners are manufactured from cold drawn tube or, if quantities justify more expensive tooling, they are made from deep drawn pressings. In either case, all machining is done before the flanges are formed; that is, the work is done on the simple cylindrical blanks. Subsequently, one end of each tube is rolled over to form the flange. In this way, flanges of up to $\frac{1}{8}$ in thick can be formed.

Apart from the saving in cost, which varies from about 20 to 23 per cent up to nearly 40 per cent when replacing some heavy section cast iron liners, the following advantages are obtained. Because the flange is so thin, it is easy to accommodate and the cooling water can be brought close to the cylinder head, where it is most needed. The wall thickness can be as little as 0·040 in for the small engines, but it increases slightly with bore size; the flange is, of course, the same thickness as the liner wall. Because of the light section of these liners, a high ratio of cylinder block wall thickness to liner thickness is obtained; this reduces the possibility of distortion and enables bore sizes to be more accurately controlled. The liners are a slip or light interference fit in their housings, and a radius of as little as 0·030 in round the housing, immediately under the flange, presents no difficulties with regard to fitting.

A demand for these liners has recently arisen because many manufacturers are seeking to find means of up-rating their engines, following the wide demand for bigger bodies and in view of the sustained high speeds envisaged for operation on new motor roads. Increases in power output can be obtained by increasing the bore and fitting these thin liners. The employment of the new liners also saves space, and engines specifically designed to take them can be made more compact. In some instances, because of the thin section of the liners, they can be fitted to engines that were not originally designed to take any liners. Further, they enable provision to be made in a simple manner for fitting liners to, for example, a diesel engine that is basically the same as a petrol engine manufactured without liners. Although at present they are only fitted dry, it may be practicable to use them as wet liners.

Among the engines that have been fitted with these new Cromard liners is a well known diesel unit, the bore of which has been increased from 3·5 in to 3·6 in, and the power thereby increased by 8 per cent. Some Coventry Climax aluminium cylinder blocks have also been successfully fitted with these thin Cromard liners for test purposes. This seems to be a logical development for a lightweight engine.

A selection of Cromard liners for a variety of applications. Their thin flanges are easy to accommodate, and enable the coolant jaccet to be brought up close to the face joint for the cylinder head

INTERIOR COOLING FOR CARS

Basic Principles of Air Cooling for Comfort, as Applied to Saloon Car Bodies

A. S. LAMBURN, A.M.I.Mech.E., M.S.A.E.

THE application of comfort air cooling, loosely called air conditioning, to passenger cars is at present in a very early stage of development in Britain. None of the popular priced cars list such equipment as an available extra, although a limited number of installations have been made on luxury class cars and limousines.

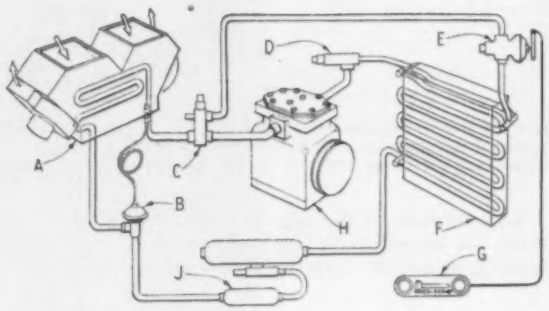
In the United States, however, where the value of comfort cooling has been widely known and appreciated for many years, considerable progress has been made in this field. Air cooling equipment was being sold in the Southern States as early as 1938, but development was interrupted by the Second World War, and no really useful work was done until the vehicle manufacturers became sufficiently interested to start developing equipment designed to meet the requirements of their own cars. In the past two or three years, production has risen rapidly until, in 1956, it reached a level of 279,000 units, of which 69 per cent were installed by the vehicle manufacturers, and total sales in 1957 reached 470,000.

The function of an air cooling system is to reduce the temperature and humidity of the interior of the car to comfortable levels when the surrounding temperature and humidity are high. It is a mistake to suppose that an air temperature of, say 65 deg F would be comfortable at all times, for example with surrounding temperatures of 95 deg F or more. Such a temperature is unnecessarily low and would cause acute discomfort to a person accustomed to, and dressed for, appreciably higher temperatures. Experience has shown that an interior temperature 10 to 15 deg F below that of the surroundings gives a satisfactory sense of comfort, particularly if humidity is lowered and if some feeling of air movement is experienced. To maintain freshness within the car, some outside air is introduced, but this quantity is kept to a minimum to reduce the load upon the cooling unit. It has been found that a total air flow of at least 200 ft³/min is necessary, of which at least one-third should be fresh.

The amount of heat that has to be extracted to maintain stabilized conditions is difficult to calculate, but is approximately as follows:

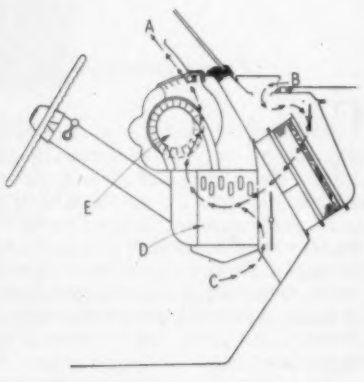
Heat to be extracted from incoming fresh air	6,600 B.Th.U/hr
Heat transmission from outside, including solar radiation	10,000 B.Th.U/hr
Heat input from four passengers	1,200 B.Th.U/hr
Total heat load	17,800 B.Th.U/hr

This rate of heat extraction is equivalent to just under 1 ton of refrigeration, where 1 ton of refrigeration is defined as a rate of heat extraction of 12,000 B.Th.U/hr, which is the rate of heat extracted by 2,000 lb of ice melting in 24 hours. While this rate of heat extraction would maintain stable thermal conditions at cruising speeds, the criterion of performance is not so much this as the ability of the air cooler to reduce in a reasonably short space of time the temperature of a heat-soaked car—that is, one that has been parked for a long period in the sun—and to maintain acceptably low temperatures when the engine is idling and when the vehicle is being driven slowly in congested traffic. It has been found that from two to three tons of refrigeration are necessary to obtain a sufficiently rapid pull-down of temperature and give a system capable of handling any load likely to be imposed on it under these conditions of operation.



A *evaporator;* **B** *expansion valve;* **C** *and* **D** *service valves;* **E** *modulator valve;* **F** *condenser;* **G** *control;* **H** *compressor;* **J** *drier*

Above: Diagrammatic illustration, showing the arrangement of the components of the vapour compression system of car cooling



Right: In this system, fresh air is joined by recirculated air, before going through the cooling unit and being discharged from the top of the dash facia

A *cooled air;* **B** *fresh air;* **C** *recirculating air;* **D** *cooling unit;* **E** *blowers*

Three methods of cooling merit consideration for application to passenger cars, namely evaporation, absorption, and vapour compression. In evaporative coolers, a stream of air passes over a water-wetted surface and is cooled by the evaporation of the water into it. Coolers of this type have been used for passenger car cooling, but their disadvantages, which include large size, slow pull-down and diminishing efficiency with increasing surrounding humidity, have resulted in their falling out of use.

Refrigeration by the absorption system, which is widely used in small domestic refrigerators, appears at first sight to offer attractive possibilities, since it might be motivated by waste heat taken either from the exhaust or the engine cooling system. The absorption system suffers, however, from disadvantages, which make its use impractical. They are: slow pull-down, aggravated by slow engine warm-up; comparatively low efficiency, with a heat extraction to power input ratio never greater than unity; and the need for appreciably greater heat exchanger surface than in the vapour compression system.

This latter system is now used by all automobile air-cooler manufacturers and is identical in principle to the majority of commercial and domestic refrigerators. Its working cycle is as follows. A volatile refrigerant at high pressure is fed in the liquid state through a throttling valve, to reduce its pressure and therefore boiling temperature, into a heat exchanger in the form of a cooling coil or evaporator. Air passed across the evaporator gives up some of its heat to the refrigerant, which then changes its state to vapour and is fed to the suction side of the compressor. In the compressor,

work is done on the gas to raise its pressure to a level at which it is capable of being condensed at relatively high air temperatures. This condensation process takes place in a second heat exchanger, termed the condenser, where heat is rejected, the refrigerant liquefies and the cycle is repeated.

The principal components employed in this system are the compressor, the evaporator, the condenser, the throttling or expansion valve, a liquid refrigerant receiver and a temperature control system, which may be either automatic or manually-operated. Mostly, the compressors used are reciprocating units of conventional refrigeration design, having a displacement of 8 to 10 in³ per revolution and capable of continuous running at speeds up to 5,000 r.p.m. The position of the compressor is determined by that of the drive from the engine.

Ideally, a constant-speed drive would be used to enable the performance of the heat exchangers and the compressor to be accurately matched to each other; at present, however, it is common practice to belt-drive the compressor at between 0·75 and 1·25 times the engine speed, giving a refrigeration capacity of approximately 1·5 tons at 1,000 r.p.m. The excess capacity of the compressor at higher speeds is largely wasted by a falling off in compressor efficiency and by the methods of control, which will be discussed later. In the last year or so it has become standard practice to incorporate an electrically-controlled clutch in the compressor drive, to permit disengagement of the compressor, either for temperature control or to avoid the necessity for removing the compressor drive belt when cooling is not required.

An evaporator of simple fin and tube construction is usually employed. It is installed, with its associated blowers, either forward of or behind the front bulkhead or, where space limitations allow, in the rear luggage compartment. Mounting the evaporator in the front of the car is generally preferred, since this enables the cool air outlets to be on or near the facia panel, whence the air can be directed on to the face and shoulders of both front and rear passengers. It has been found that the greatest sense of comfort is obtained when the cooled air is discharged at a relatively high level from the front of the car. Under no circumstances should cold air be permitted to strike the back of the head and neck. Forward mounting of the evaporator gives not only the considerable advantage of a simplified installation, but also enables the unit to be combined with a conventional hot-water type air heater. This arrangement further simplifies the installation, inasmuch as certain components, for example, blowers, which are necessary to both the cooler and the heater, need not be duplicated. A combined air heating and cooling unit can be used to control fully the temperature and humidity of the air within the car and is the nearest approach so far made to complete air conditioning.

The condenser, also usually of fin and tube construction, must be mounted in a moving air stream, so that it can reject effectively the heat extracted from the interior of the car, together with the heat equivalent of the power absorbed by the compressor, some 25,000 B.Th.U/hr in all. It is also necessary to arrange to pass air over the condenser when the car is stationary. Therefore it is usually placed in front of the engine cooling radiator, to take advantage of the radiator fan, although this is not an ideal position. Considerable care must be taken to position the condenser so that it does not have any adverse effect upon the engine cooling system.

Owing to their large size, in relation to the space available, the three components described above are those which are the most difficult to design and accommodate. All the other units are small and are readily placed in the most convenient positions available.

The most widely used refrigerant in automotive applications is Refrigerant 12, dichlorodifluoromethane. This material, one of a recently developed range of fluorinated hydrocarbons, boils at — 21 deg F under atmospheric pressure. It is non-inflammable, non-toxic, odourless and tasteless.

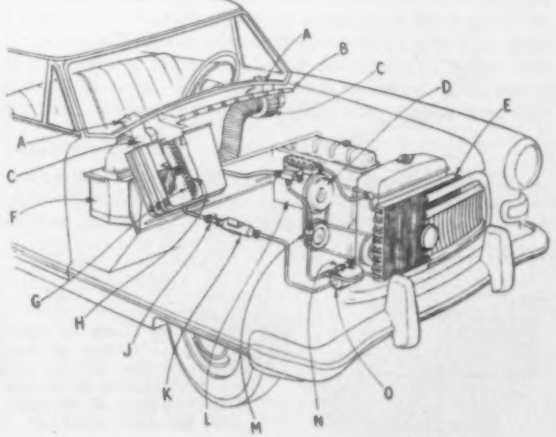
Temperature of the air emerging from the cooling unit may be controlled automatically, by thermostatic or pressure-sensitive devices, or manually. Broadly, two systems of control are available. They are: on-off operation of the compressor, and capacity control by means of a by-pass circuit. On-off control of temperature, by a thermostatic switch and electrically-operated clutch in the compressor drive, has been used to regulate the temperature of the air emerging from the cooler or the surface temperature of the cooling coil. A disadvantage of both these methods is that, as the compressor cuts in and out, noticeable changes occur in the running of the car. Also, the drive components may tend to wear rapidly. Control of the air temperature offers no protection against evaporator frosting at high speeds and in conditions of low ambient temperature, while control of the surface temperature of the cooling coil gives poor regulation of the temperature of the air in the car with changes in ambient conditions.

It would appear that the most satisfactory method of control is to modulate the capacity of the system by means of a by-pass connected across the discharge and suction ports of the compressor. By this means, only the quantity of refrigerant necessary to give the desired cooling effect is fed to the evaporator, the remainder returns directly to the compressor. The rate of by-pass may be controlled automatically by a thermostat and solenoid valve or manually by a mechanically-operated valve, which can also be made sensitive to the evaporator pressure and thereby provide protection against evaporator frosting.

The ultimate design objective for passenger car comfort cooling must be a completely packaged system that can be quickly and easily installed in a similar manner to the present heating units. It seems fairly certain that a constant-speed drive, either hydraulic or electrical, will be developed for the compressor and that simpler control systems will be evolved. However, it is clear that although air cooling equipment will probably be offered as an optional extra on the majority of medium size and some small British cars in the fairly near future, rapid development and general acceptance of air coolers will not occur untill allowance for its inclusion is made in the earliest stage of the design of new vehicles.

Nash All-Weather Eye air conditioning system, in which both the cooling and heating units are installed together under the bonnet of the car

A *discharge ducts;* **B** *fresh air intake;* **C** *blowers;* **D** *electric clutch for compressor;* **E** *condenser;* **F** *cooling unit, or evaporator;* **G** *heating unit;* **H** *fresh air filter;* **J** *inspection glass;* **K** *filter;* **L** *compressor;* **M** *solenoid valve;* **N** *check valve;* **O** *receiver*



NUTS AND BOLTS

Discussion of Some of the Factors Affecting Strength and Fatigue Resistance

NUTS and bolts are so commonly used that they are apt to be taken for granted. However, a detailed analysis of stress distribution under different types of loading and of their design is both rewarding and interesting. A most useful collection of facts on this subject is presented in a paper entitled "Fatigue of the Nut and Bolt", by P. B. Walker, C.B.E., M.A, Ph.D., F.R.Ae.S., published in *The Journal of the Royal Aeronautical Society*, June 1958. Some of the interesting points raised are given in the following abstract, and many more are discussed in the original article.

The object of the paper is to collect together and examine the main factors that tend to reduce the fatigue life of a nut and bolt loaded in tension. Individually, many of these adverse factors are well known, but the aim is at producing a single comprehensive picture with them all shown in relation to each other. In particular, an attempt is made to demonstrate how the adverse effects can be deduced from basic structural theory. This calls for a fairly detailed study of the stress pattern in a tension bolt; and it is shown that this commonplace item of everyday engineering must be recognized as one of the most complex structural elements in existence.

A most important conclusion drawn is that some of the main causes of early fatigue failure do not arise directly from the use of screw threads. There are issues that are more fundamental, and these are attributable to the basic method of loading, in which tension in the bolt is produced by peripheral shear forces applied by the nut. The screw threads come into this picture mainly as a device for transmitting shear in a most effective way, and the stress concentrations and discontinuities they introduce are an additional significant feature.

It is of interest to note also that the fatigue behaviour of any given nut and bolt combination is not an intrinsic property, but depends as much upon the characteristics of the structural elements that are held together. For investigation of some of the adverse factors, therefore, the nut and bolt have to be considered as part of a complete joint assembly. The structural deformations under load, in particular, may be a major complication and they probably introduce the greatest element of uncertainty in the overall problem under examination.

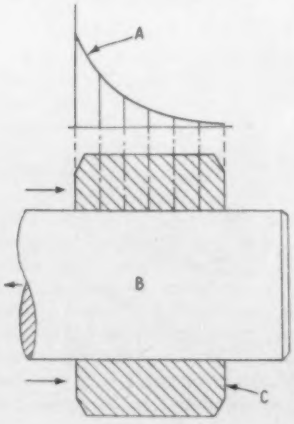


Fig. 2. This illustration shows the general pattern of load transfer between the nut and bolt. **A** *is the curve of intensity of shear loading,* **B** *represents the bolt and* **C** *is the nut*

Mention has to be made, also, of plasticity at high stress and of pre-tensioning. Both of these, either separately or in conjunction, can modify considerably the adverse effects that are brought out in the analysis. Plasticity, while contributing to a relaxation of high local stress, is not difficult to treat as a modification to elastic theory. Pre-tensioning, on the other hand, is a major complication, mainly owing to the wide variation in the degree of initial tension that might be imposed, and the possibility that there may be no initial tension at all.

Stress diffusion and shear lag

For the initial analysis, the nut can be considered as a simple collar, and the bolt as a plain rod, as shown in Fig. 1. Since the threads are simply a practical and effective method of transmitting shear force from the bolt to the nut, that is, they prevent the nut from sliding along the bolt, it can be assumed that their function is performed by a suitable adhesive. For this idealized case, it is at once clear that the nut can apply

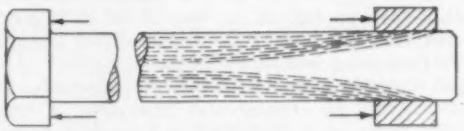


Fig. 1. For the purpose of the basic stress analysis, the nut can be considered as a collar secured by an adhesive to the bolt shank. The dotted lines indicate the general form of the stress diffusion from the area of application of the load, at the nut, into the bolt

load directly only to the outer fibres of the bolt. The conception of stress in tons per square inch, based on total cross sectional area, is thus misleading, since in the region of the nut, the inner fibres of the bolt carry scarcely any load at all. If the stress pattern in the bolt is followed, proceeding from the nut end towards the head, it can be seen that the stress gradually diffuses inwards in a way that is roughly represented by the tension lines shown in Fig. 1. This is the shear lag effect that is well known in structural engineering, and which operates in addition to any effects directly attributable to the threads.

A similar stress diffusion phenomenon may occur also at the bolt head, even though the material is continuous and has no surface of separation. This is probably one of the reasons why, in fatigue tests made in the laboratory machines, the bolt occasionally fails at the head instead of at the more usual place, under the nut face, where the shear loading is highest, Fig. 2.

The tendency for stress to be concentrated in the outer fibres has a bearing on the practice sometimes followed of drilling a hole along the axis of the bolt. This removes material that apparently does little useful work, since the central core of a solid bolt carries little stress in the region of the nut and elsewhere relief of stress is not required. A hollow bolt is thus rather more efficient than a solid one on a strict weight-strength economy basis, but it has to be borne in mind

that the central material of a solid bolt is not entirely useless, since it attracts stress away from the critical outer fibres. The main valid argument for a hollow bolt is its increased flexibility, which is beneficial when advantage is being taken of pre-tensioning—a subject that will be discussed later.

Shank constraint and interference

The simple rod and collar conception can be modified, as shown in Fig. 3, to make it more truly representative of a nut and bolt. This modification is necessary because the shank of the bolt is of larger diameter than the effective load-carrying core of the threaded portion.

Concentration of stress takes place at the nut face, marked X in Fig. 3. This is partly due to uneven distribution of the applied peripheral shear loading and partly to shear lag. On both counts the intensity of the stress concentration depends on the rigidity of outer fibres, just inboard of the nut face. These provide the anchorage without which the stress concentration could not be sustained. The extra material in the shank stiffens the outer fibres and so gives an additional degree of rigidity and intensifies the stress concentration.

The second adverse factor, which is referred to as shank interference, occurs only when the nut is close to the shoulder. It is convenient to approach this condition in stages and to consider first the case of a nut separated from the shoulder by a short distance. In the stress field for this case, there are two rings of stress concentration. One is the nut face concentration X; the other is the concentration at the shoulder Y, which is of the kind ordinarily present whenever there is an abrupt expansion or contraction of the stress field. With an appropriate degree of separation of these two planes, the two concentrations do not greatly affect each other.

If the nut is now brought progressively nearer to the shoulder, the two concentrations begin to react on each other and produce mutual aggravation. Ultimately, when the nut reaches the shoulder, the two are almost completely superimposed.

It is clear that to prevent shank interference, there must be a reserve of thread between the nut face and the beginning of the shank. This reserve must be additional to that which represents the tolerance for the tightening of the nut. Methods of accommodation of unused thread may be important and need special attention in design to avoid introducing additional troubles. Three recognized methods are illustrated in Fig. 4. One has the simple washer as shown at a, and another, at b, has the counterbored nut, in which some of the turns of thread are removed internally. The third measure, shown at c, is to allow the unused thread to pass into the hole. This latter arrangement does not appear to be favoured in first-class structures, since it is not good when shear loads have to be transmitted; however in many cases, it may be preferable to having an inadequate allowance of unused thread.

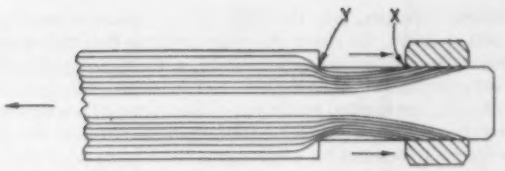


Fig. 3. This modification of the basic conception of the nut and bolt combination, as depicted in Fig. 1, takes into account the fact that the core diameter of the threaded portion is appreciably smaller than the unthreaded portion of the shank. It can be seen that there are two stress concentrations, one at the discontinuity of section at **Y** *and the other at the nut face* **X**. *If the points* **X** *and* **Y** *are too close together, these two stress concentrations are superimposed on one another*

In Fig. 5, three methods of overcoming the two adverse effects of the shank are illustrated. All three have two serious defects: the bolts in the forms illustrated are not satisfactory for transmitting either shear or bearing loads, and they do not give positive location of the structural components that they secure.

A method of greater practical significance is the employment of a circular groove between the end of the thread and the shank. Although its effect on shank constraint undoubtedly is small, stress concentration is reduced in two ways. Since the groove is circular and therefore continuous, it can be made with a higher degree of accuracy and smoothness of finish than is possible for a spiral. In addition, its shape and form can be selected to give the smoothest possible transmission of stress into the shank.

Stress concentrations at the threads

The lag in the inward diffusion of stress causes a heavy concentration of stress lines round the relatively sharp notch at the trough of each thread. In addition, the effect of the bending moment in the thread, which is at a maximum near the root, is superimposed. Other adverse factors that have to be considered are irregularities and imperfections of the threads on both the nut and bolt, which may cause one turn of the thread of the bolt to be more heavily loaded than it otherwise would be. These irregularities and imperfections may improve or worsen the load distribution, according to their position and nature.

There is also liable to be a pronounced stress concentration at the termination of the thread, that is where it runs out. To a large extent, this concentration is inevitable from geometric considerations alone, but experience shows that it is often aggravated by imperfections of manufacture, which are difficult to avoid. This defect can be obviated by the use of a circular groove, as described under the previous heading.

Eccentric loading

Eccentric loading, and consequently a superimposed bending moment, can be produced in two distinct ways. One is by relative inclination of the contact faces of the nut and the

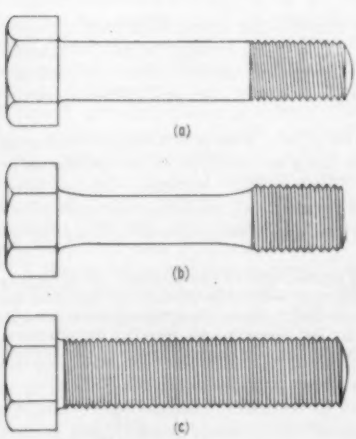


Fig. 5. Left: There are three commonly employed methods for the elimination of stress concentrations due to shank effects. At **a**, *the shank of the bolt is reduced to the core diameter of the thread, at* **b** *the shank of the bolt is waisted, and at* **c** *the thread is continued over the entire length of the bolt shank*

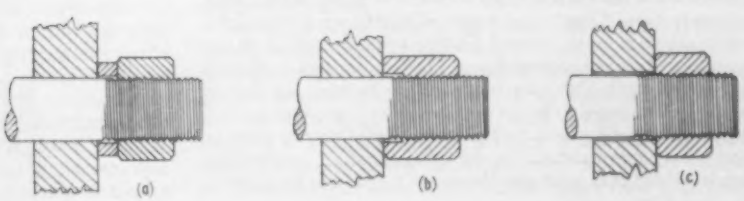


Fig. 4. Right: Three methods of accommodating idle turns of thread. At **a**, *a thick washer is employed, at* **b** *the nut face is counterbored, and at* **c** *the thread extends into the bolt hole*

adjacent structure, and the other is by deformation of the structure itself. In either case the result is that the tensile force on the bolt is not applied axially, so the bending moment is superimposed. A significant factor is that this bending moment is not applied in the more usual way, by a transverse shear, but by forces parallel to the longitudinal fibres; whereas the distance required for a transverse shear force to produce a significant bending moment encourages a proper distribution across the section, no such effect is present with longitudinal loading.

Even with a properly distributed bending moment, following the convention theory, the maximum tensile stress occurs at the maximum distance from the bending axis. In consequence, its effect is greatest at the already critically loaded outer fibres. In practice the situation is still worse, since bending moment applied by the nut to the bolt is more unfavourably distributed: the load can be applied only at the outer fibres, and there are also the effects of shear-lag, already considered for direct axial loading.

Eccentric loading and a superimposed bending moment can be produced in two distinct ways. One is by inclination of the contact faces of the nut and the adjacent structure. The other is by deformation of the structure itself.

To reduce the adverse effects of mutual inclination of the contact faces, it is well worth while to round off the corners of the hexagon face of the nut. When spherical seating nuts are employed and the centres of the spherical surfaces are not concentric, Fig. 6, a spherical seating not only has no particular advantage, but also may have a powerful wedging action, the effect of which can be even worse than that of inclined flat faces.

This disadvantage can be overcome by employing a washer with a spherical seating face machined in it. An essential feature of such a washer is that it must also have an over-size hole, so that it can slide over the face against which it bears, until the centres of the spherical faces coincide, Fig. 7. In these circumstances, although the resultant force applied to the bolt is slightly inclined to its axis, the effect of the inclination is small.

Structural distortion

Two typical examples of structural deformation are illustrated in Fig. 8. The externally applied force produces a bending moment in the structural element in the region of the nearest bolt. This has to be balanced by a compressive force applied at the contact faces of the two structural elements. The load in the bolt is therefore increased by an amount equal to the resultant compressive force. The magnitude of this increase depends on the position of the centre of pressure, which in turn depends on the flexibility of the structural element. It can readily be shown that the extra tensile load induced increases with increase in flexibility of the structure.

When the loading is in shear, as in Fig. 9, the overall effect is much the same as for the tension case; and, whether the nut rests on an edge or makes full contact, a bending moment is applied. For a well designed and well made joint, the bending moment may be small. The adverse effect, however, can be greatly magnified if the bolt is a loose fit in the hole and the structural components are able to slide over each other.

Plasticity

The most direct effect of plasticity under fatigue loading conditions is the relief of high local stress in regions of stress concentration. Clearly, the degree of benefit arising from this effect depends on the overall loading level, as well as on the existence of stress concentrations. Thus, most relief is afforded at loading levels that may be judged to be high for fatigue loading conditions, although not so high as to produce universal or widespread plastic deformation. Relief may be small or completely non-existent, on the other hand, at low loading levels, which may have significance if they occur frequently,

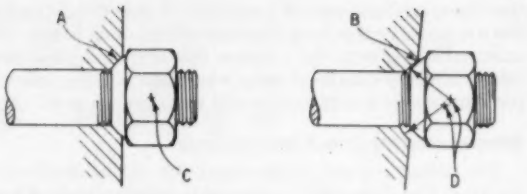


Fig. 6. On the left is shown a correctly seated spherical nut, which makes full contact at **A**; *both the seating and the spherical end of the nut have a common centre at* **C**. *In the right-hand illustration, the axis of the bolt is not truly perpendicular to the face of the structure, with the result that the centres are displaced, as shown at* **D**, *and the spherical surface on the nut seats eccentrically at* **B** *thus applying a bending moment to the bolt*

for example, when produced by vibration of the structure.

The permanent deformation that occurs at high load appears to produce benefits at lower loading. In effect, the structure is preformed to a shape that gives a more or less permanent reduction of maximum stress in the region where plastic extension has occurred. However, the phenomenon is not so simple as might at first sight appear. The plastically deformed material tends to behave elastically at the lower stress, and hence the range of load variations may be unchanged, and at very low tensile loads there may be local compressive stress.

In addition to its effects on the internal stress pattern, plasticity may also exert a beneficial effect on the distribution of applied force at the threads of the bolt. It may do so in two distinct ways. In the first place, plastic deformation tends to iron out small excrescences and to correct any minor irregularities. In the second place, it can go some way towards equalizing the loads carried by the turns of thread: the critical turn at the nut face may yield under heavy load and cause a greater share to be transmitted to the next; this may also shed load, and so on down the line, to an extent depending on the magnitude of the tension load applied to the nut and bolt.

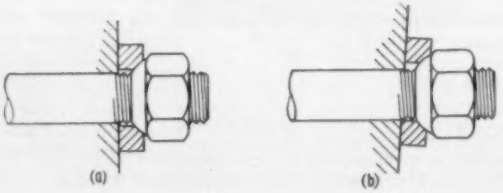
Pre-tensioning of the bolt

There is one major reservation concerning the beneficial effect of plasticity on the screw threads. The loading level necessary to produce the relieving effect to a significant degree is probably greater than will normally occur under acceptable conditions of fatigue loading. It has, therefore, to be brought about artificially, and the method is pre-tensioning of the bolt.

Pre-tensioning may improve the thread form and therefore the load distribution. It may also reduce the rate of tension load fluctuations and alleviate the adverse effects of inclined bedding faces. Further, it leads to a general stiffening of the complete joint.

To obtain the desired effects, a fairly heavy pre-tensioning is necessary, although there are differences of opinion as to the precise degree. Many skilled operators tighten until yielding is definite and obvious. It is probable that such yielding, which is detected partly by observation of the number of

Fig. 7. A spherical seating washer, with an over-size hole, can be used to overcome difficulties associated with misalignment of the bolt, as depicted in Fig. 6. At **a**, *the bolt is shown correctly aligned relative to the structure, while at* **b** *it is out of true but the spherical end of the nut is correctly seated, on the washer and the spherical centres are coincident*



turns and partly by feel, is confined to the threads. This degree of tightening appears to be adequate, and it is probably undesirable, as well as unnecessary, to proceed to a stage where general yielding of the main body of the bolt occurs.

In principle, the improvement obtained by one tightening is permanent. Experience shows, however, that it is important that tension should be maintained by further tightening at regular intervals. The bedding down process, which takes place not only at the threads, but also at the contacting faces of the structural elements comprising the joint, is progressive under the action of the fluctuating loads that are superimposed on the steady tension load. Left to itself, the originally tight nut becomes slack and may rotate slightly. In this event, much of the benefit of thread pre-forming is lost. On the other hand, if tension is maintained, the progressive bedding-down at the threads is beneficial. It is of interest to note that the other benefits to be derived from pre-tensioning require the tension to be continuously maintained.

Reduction in range of the fluctuating tension imposed by the operational loading arises from the relative flexibility of the bolt in tension and the comparative rigidity in compression of the structural elements that are clamped together by the nut and bolt. If, for example, the bolt under tension expands ten times as much as the structure contracts under the corresponding compression force, then only one-eleventh of the load fluctuation passes through the bolt. The remainder passes through the structure, which being in compression is not, as a rule, vulnerable to fatigue.

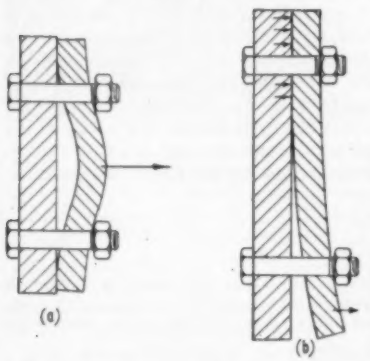


Fig. 8. Two modes of structural distortion under tensile load. At **a** *the load is applied symmetrically and at* **b** *it is offset. With either mode, a bending moment is applied through the nut face to the bolt*

Clearly, pre-tensioning should not be relied on to bring together two surfaces inclined originally at several degrees to each other. On the other hand, manufacturing accuracy is not absolute and it appears reasonable to assume that a small angle of inclination can exist in spite of the care taken. Without pre-tensioning, therefore, there must exist some low loading level, at which the entire fluctuating axial load is applied non-axially at an edge or corner of the nut. The associated bending moment is then far more damaging, from the fatigue standpoint, than the axial component of tension, although only a small degree of pre-tensioning is required to remove it entirely.

A benefit of pre-tensioning arises from the general stiffening of the structure that it produces. Without pre-tensioning, the non-axial loading effects depend primarily on the flexibility of the particular structural element immediately under the nut face. Pre-tensioning clamps all the elements together and in general, gives a considerable increase in overall effective stiffness. The benefit is obtained in both tensile and shear loading cases. Closely allied to this direct stiffening effect is the prevention of fretting that may arise from a general looseness in the complete joint unit. Fretting cannot necessarily be eliminated entirely by pre-tensioning, or in fact by any other means, but it is rendered much less likely to occur.

Great care is necessary in carrying out pre-tensioning. The main danger is over-tightening. It is possible of course, to break the bolt, but still worse, a crack may be initiated, and this may not be detected at the time, but may quickly extend as a result of fatigue. A most successful method of tightening is the use of a spanner with a torque limiting device. It has been said, however, that the hand of a skilled operator is far superior to the best torque spanner ever made. For this view, there may be some justification. Nut and bolt combinations vary considerably in their inherent resistance to turning, and whereas a skilled operator unconsciously allows for this, the torque spanner operates indiscriminately.

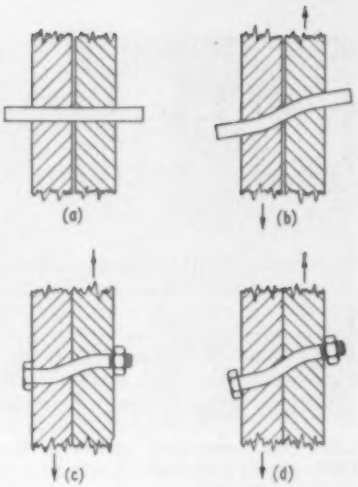


Fig. 9. Four diagrams showing the effects of shear deformation on the loading of a bolt. The diagram at **a** *shows the unloaded condition; at* **b** *shear deflection has occurred and the rod is deformed; at* **c** *the completely encastré condition is depicted, while* **d** *illustrates the occurrence of partial end fixation*

Choice of material for the nut and bolt is also of prime importance. Materials liable to stress corrosion should not be used, since they may fail under the steady load. It is worth while, moreover, to sacrifice ultimate strength in order to have a material of a reasonably high ductility. This introduces a much greater degree of tolerance in the pre-tensioning process, so the risk of over-tightening is greatly reduced, while it is less difficult to ensure adequate tightening.

Conclusions

In the original paper, the author discusses twelve adverse factors tending to reduce fatigue life. The number alone has significance. Its implications are that information obtained from laboratory tests must normally be accepted with reserve owing to the difficulty of reproducing all the adverse factors realistically, especially those originating from the structure.

Among the several conclusions that the author draws, the following is perhaps the most significant. The most important characteristic of the collective list is the way in which several adverse effects may be superimposed. For simple stress concentrations, such as are produced by holes and notches, it is usual to assume in fatigue investigations a realistic stress factor of three or four in the worst conditions. In a complex stress field, however, one stress concentration may virtually be multiplied by another, provided that the term stress concentration is interpreted in its broadest sense. Thus, for example, a notch concentration may be situated in a congested stress field produced by shear-lag, and this in turn may be aggravated by an initial concentration of applied load on entry into the stress field. Furthermore, the high local stresses induced may be greatly intensified by eccentricity of the applied loading.

Instead of being three or four times the nominal average, therefore, the effective maximum stress from the fatigue standpoint can easily be ten times the nominal average. This figure of ten is believed to be approximately the best assessment that can be made from the experimental evidence at present available from all sources. In the light of this analysis, however, it is suggested that the possibility of still higher values, for particularly adverse combinations, cannot be dismissed.

FUEL CONSUMPTION MEASUREMENT

Precision Electronic Apparatus for Accuracy of Recording Consumption of Small Volumes of Fuel

IN the laboratory or engine test house, electronics can be enrolled to assist the automobile engineer to measure fuel consumption accurately and rapidly. This has been successfully done by Farnell Instruments, Ltd., of Hereford House, North Court, Vicar Lane, Leeds 2, whose electronic fuel consumption testers are used by Leyland Motors Ltd.

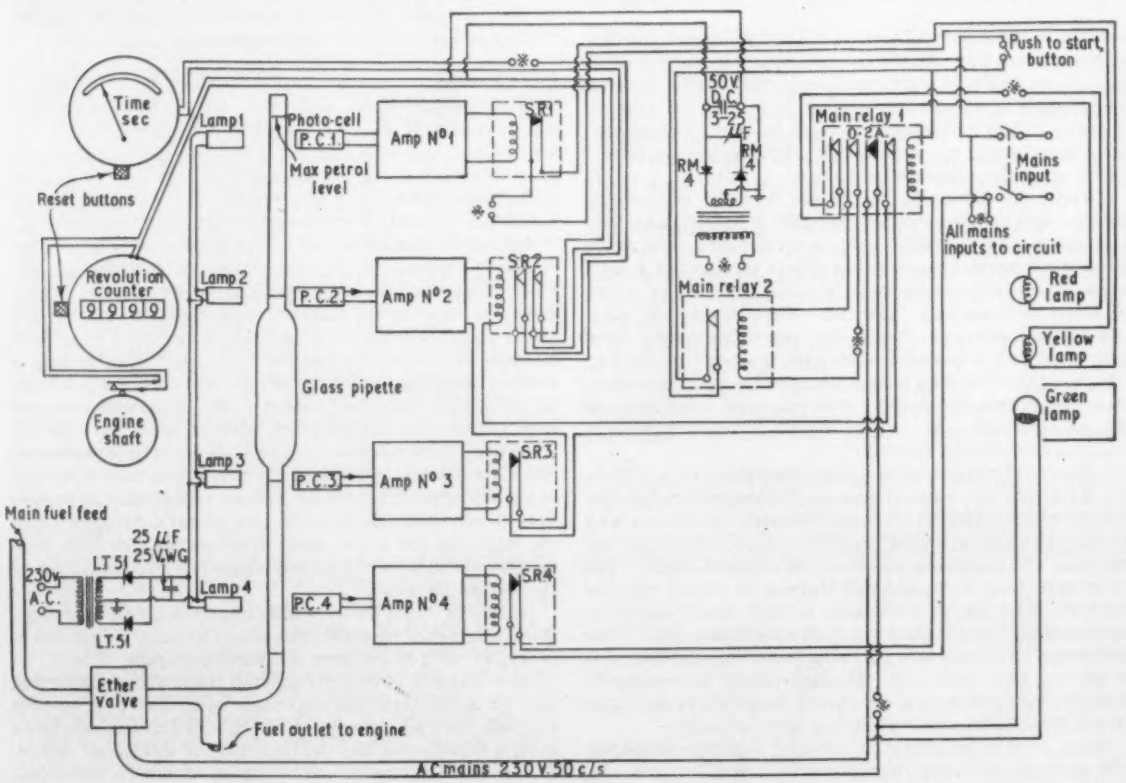
This equipment occupies a metal cabinet measuring 36 in × 20 in × 10 in, suitable for wall mounting. There are three basic measuring devices: a burette, which can be 157·8 cm³ or 1,578 cm³, to choice; a Dowty engine-revolution counter reading up to 999,999 and a Synclock time interval meter, counting from 0 to 30 minutes in seconds and fractions of seconds. The external connections comprise A.C. mains leads, 200 to 250 volts, single-phase 50 c/sec; fuel feed pipes; and a jack, to connect the contactor unit to the engine under test and so to operate the revolution counter. Three indicator lamps show stages in the operation of the apparatus, and automatic resetting has been incorporated. To avoid tabulating errors, however, the engine revolution and time indicator dials are manually reset. The apparatus can be used to measure the consumption of any liquid that is opaque or coloured.

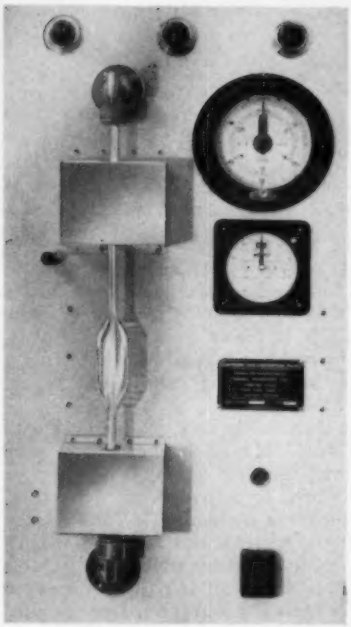
Electronically, the circuit consists of four lamps and their associated photo-electric cells, with the necessary amplifiers and energizing relays to control the operation. About ten seconds are required initially for the amplifiers to warm up; after this, the tests are controlled by the start button just under the nameplate on the instrument panel.

When the mains switch is closed, the Ether valve, which is named after its inventor, is energized; this is a straightforward solenoid-operated valve, which opens the main fuel feed and permits fuel to flow to the engine under test and to fill the burette. A green indicator lamp, in parallel with the valve, is illuminated, showing that the valve is open. The fuel in the burette rises until it refracts the light from lamp (1); this causes relay SR1 to close and illuminates the yellow indicator lamp to signify that tests can begin. Meanwhile, the engine under scrutiny has been started, and is run on the fuel passing from the storage tank through the Ether valve.

When the start button is pressed, the Ether valve is closed

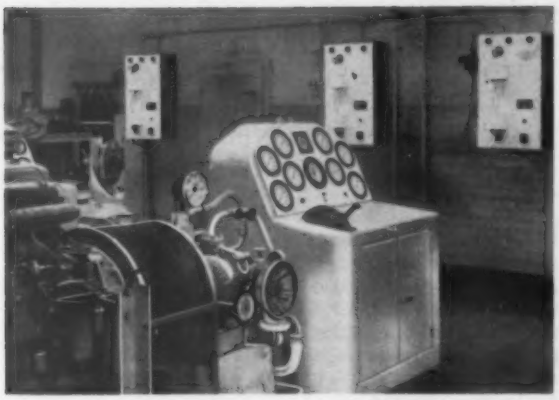
The sequence of operations of the engine fuel consumption tester are as follows: 1, all mains on, Ether valve opens and green light comes on; 2, when the amplifier is ready and the petrol level normal, the yellow lamp is illuminated; 3, operation of the press-to-start switch illuminates the red lamp, closes the Ether valve and switches off the green lamp—if the system is functioning correctly the yellow lamp goes out within a few seconds, indicating that petrol is being used; 4, when the yellow lamp is illuminated again, the test can be repeated by pressing the start switch





Left: Close up view of one of the cabinets containing the electronic fuel consumption test equipment

Right: A view of an engine test department, where three electronic fuel testers are mounted on the wall in the background



and the green lamp extinguished; then the engine draws its fuel solely from the burette. At the same time the red lamp is lit, indicating that a test is under way, and various relays are operated: SR3 closes to complete the circuit through the relay coil of amplifier No. 2, and main relay (2) closes to connect the mains supply directly across main relay (1), which is necessary to maintain the *status quo* of relay (1) after the start button has been released.

The level of the fuel in the burette then starts to fall, a fact which will be indicated by the extinguishing of the yellow lamp as the level drops below lamp (1) again. As it drops below lamp (2), photo-cell (2) responds and its amplifier closes the contacts in relay SR2, which sets in operation the time interval recorder and the revolution counter. Between lamps (2) and (3), therefore, is the portion of the burette containing the critical volume of fuel, the consumption of which is measured on a time/engine-revolution basis.

As the liquid level passes lamp (3), amplifier (3) opens SR3 relay. This opens SR2 relay and stops the time interval recorder and the revolution counter. The fuel level continues to fall until it passes lamp (4), whereupon the impulse from photo-cell (4) causes its associated amplifier to open relay SR4. The opening of SR4 breaks the circuit to main relay (1), and main relay (1) de-energizes main relay (2). The cycle thus concludes with the opening of the Ether valve, the extinguishing of the red lamp and the re-lighting of the green.

Subsequently the engine continues to run, taking its fuel from the storage tank through the Ether valve, and the burette is refilled. As the fuel level rises past the photo-cells, SR4 relay closes; similarly SR3 closes in its turn, followed by SR2. However, since the mains supply is interrupted and main relay (1) is open, nothing will happen. When the fuel rises past photo-cell (1), relay SR1 closes, lighting the yellow indicator lamp and permitting another test to begin as soon as the time recorder and revolution counter dials have been reset to zero.

The basic circuit of the amplifiers embodies a trigger tube operating from transformer-rectifier-supplied direct current at 150 volts. When the grid of the valve is energized by an impulse from the photo-electric cell the trigger tube strikes, operating the relay incorporated in the anode circuit. Similarly rectified and transformed current at 50 volts operates the revolution counter, while the photo-electric cell lamps are served by 6·3 volts alternating current.

CORROLESS PRIMING PAINT

A PAINT that gives anti-corrosion resistance by stabilization of the rust on the surface of the steel has recently been introduced into this country. Corrosion has always been a serious problem because, before a steel surface is painted, its preparation in such a way that it is absolutely free from rust, is virtually impossible. Moreover, freedom from porosity of the paint film, and therefore perfect protection over a long period, is extremely difficult to obtain. In fact, progressive corrosion of the iron beneath the coat of paint tends to continue.

Exhaustive investigations have shown that stabilization of the surface rust can be an important factor in the successful control of corrosion. It has been found that the outer layers of Fe_2O_3 and Fe_3O_4 of the mill scale are stable, and that further deterioration is caused by the unstable inner layer of FeO. As a result of this discovery, research has been directed towards the control of corrosion by stabilizing the layer of FeO and forming a permanent union between it and the iron foundation.

This led to the development of Corroless priming paint, which contains in its pigment active substances to effect the necessary chemical change in the composition of the rust. These substances initially give cathodic protection to the iron surface, and then gradually reduce the rust to Fe_2O_3 and Fe_3O_4. Owing to the close union of these compounds with the iron foundation, this process is irreversible. Further details can be obtained from Modastic Ltd., of Vesta Street, Ancoats, Manchester 4.

GWISH FIRE EXTINGUISHER

AN inexpensive and compact fire extinguisher installation is offered by Deb Chemical Proprietaries Ltd., of Forfar Works, Belper, Derbyshire. It comprises a metal can, in which carbon tetrachloride is stored under pressure. The pressurized gas is dichlorotetrafluoroethane, which is also a good non-toxic extinguishing fluid. The contents of the can spray out when a valve at its upper end is pressed, and the flow is checked when the valve is released. A dust cap is fitted over the valve when the extinguisher is not in use. The can is about 6¼ in long × 2¾ in diameter; it is supplied together with a light bracket by means of which it can be fixed to a wall or a piece of machinery.

Semi-Trailer Couplings

Arrangement Designed to Facilitate the Operation of Mixed Fleets

H. C. Rippon, A.M.I.P.E.*

ONE of the most vexing problems to operators of large mixed fleets of semi-trailers and tractors is the wide variety of king pin and other types of coupling in use. This prevents interchangeability of tractors and semi-trailers, and restricts the use of different makes of semi-trailer. Currently, the position with regard to modern fleets is improving, since most manufacturers now fit the interchangeable SAE/SMMT king pin on their semi-trailers.

A few years ago, there were at least nineteen different types of coupling available, and a large proportion of these are still giving good service. Currently, a type mainly used is the Scammell Mechanical Horse, or MH, type: this is also offered by Hands, Brockhouse and Taskers; in addition, the Karrier J type is popular. These are all undoubtedly of great value so far as quick detachability and coupling are concerned, particularly for operation in cities and towns, where coupling and uncoupling is performed many times a day.

Unfortunately, earlier models with these types of coupling had cross beams, the load-carrying capacity of which was restricted to 4¼ tons. Also, for some applications, a larger diameter turntable would be useful: otherwise, when high loads are carried, rocking on the central pin may be troublesome. Improvements have, however, been made to bring these types into line with modern requirements, and they certainly have a great deal to offer where quick turn-round is essential. For heavier loads, the SAE/SMMT king pin appears to be favoured by most fleet owners, and there is a wide variety of interchangeable types of semi-trailer available for loads up to about 40 tons.

It would appear that rationalization in design might be attained by adopting the MH types of coupling for loads up to a maximum of about 12 tons, and using the SAE/SMMT type of king pin for the heavier vehicles from, perhaps, 10 tons upwards. However, turn-round with the king pin type couplings is relatively slow, because the handbrake has to be applied, the supporting legs wound down, the turntable lock released and electric and brake leads disconnected.

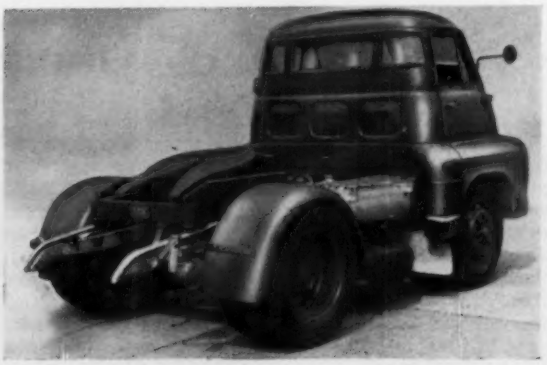
Owing to the wide differences between designs, it has not been possible hitherto to interchange either the tractors or semi-trailers with the two types of coupling. Although a detachable SAE/SMMT turntable can be used with tractors fitted with MH coupling gear, this is only available where stored. So, to adapt a tractor for universal application, that is, for coupling to semi-trailers equipped with either an MH coupling or an SAE/SMMT king pin, a new type of turn-over fifth wheel mounting has been developed and is now marketed by Fox Trailers Ltd., of Speke, Liverpool. The tractor carries the lower half of an MH coupling gear, above which is a standard SAE/SMMT turntable fitted to a base plate, which is hinged at its forward end so that, when not in use it can be swung over, to lie snugly on the frame behind the cab, that is, in front of the MH gear.

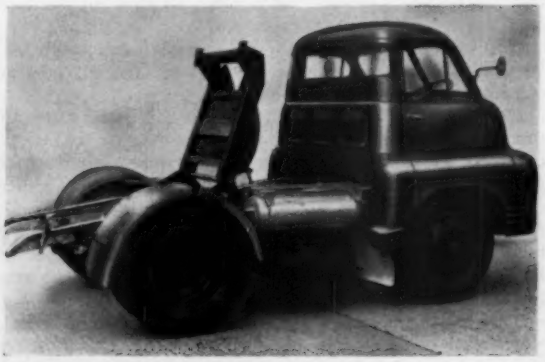
This tractor unit can therefore be operated normally with semi-trailers equipped with MH type couplings; then, when it is required for use with the SAE/SMMT king pin type semi-trailers, the fifth wheel, or turntable, is swung over, through 180 deg, and locked in position. Thus the vehicles in mixed fleets of semi-trailers with MH and SAE/SMMT couplings can now be made interchangeable. A detachable adapter is available, also, to convert an SAE/SMMT king pin equipped semi-trailer for use with a tractor fitted for operation with MH couplings.

Although it is hardly likely that truly interchangeable couplings will be available at least for some years, the advantages of interchangeability are now obtainable by having two types of coupling on one tractor. Fox Trailers Ltd. have also directed their attention to the speeding-up of operation of the supporting legs of the heavier semi-trailers. This can now be effected by fitting an electric drive gear to actuate the legs, but retaining also the manual means of operation. In view of the increasing development of Irish and Continental ferry services, methods of speeding the handling of different types of semi-trailer undoubtedly will be welcome.

*Vehicle consultant, of Rippon Bros., Woodend Avenue, Speke, Liverpool 24.

These three illustrations show details of the new dual coupling fitted to a tractor





New Plant and Tools

Recent Developments in Production Equipment

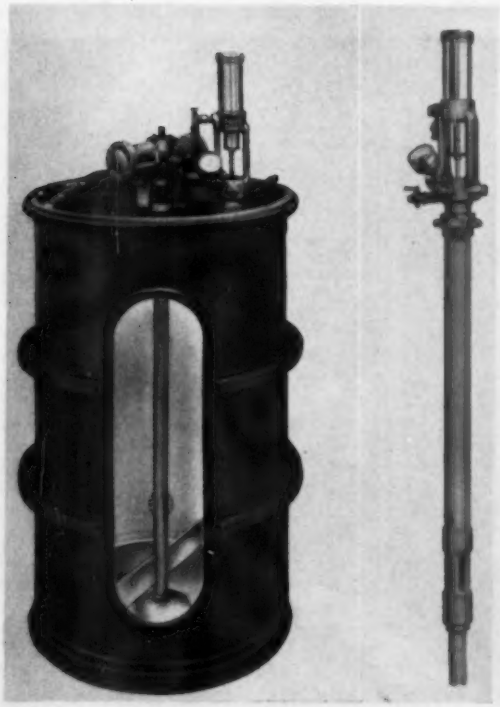
IT is still fairly common practice to purchase paints or other finishing materials in bulk containers and then transfer them to other containers for use in the shops. Since the manufacturers will now supply paints at a specified viscosity, ready for use, it would seem more logical to use the material direct from the bulk container. To take advantage of this facility the American-built Binks "Pogo" materials handling pump was introduced some time ago by Alfred Bullows & Sons, Ltd., Long Street, Walsall, Staffs. The pump is now being manufactured by the firm, under licence from the Binks Manufacturing Co. of Chicago, U.S.A.

The pump is of the direct-acting, reciprocating type, and is air-operated directly from the shop air line. Pressure ratio is 2·5 : 1, that is, a delivery pressure two and a half times the air line pressure is developed. Maximum rate of delivery is 1 gal/min, with the pump operating at approximately 150 double strokes/min. Pump speed is adjustable and for continuous running, it is recommended, should not exceed 125 double strokes/min. Air consumption, varying according to operating demands, will range from 3 to 6 ft^3/min.

One pump can feed up to six spray guns direct from the drum, providing that the piping size is adequate. Either a "dead-end" system or a circulating system can be arranged. A circulating system is virtually essential if materials such as pigmented paints, which could settle out in the pipe lines, are to be handled. The pump will provide a steady flow of material since it is of the double-acting type delivering on both up and down strokes. Low maintenance cost and long working life would seem to be assured as the operating speed is relatively low.

A pressure control device, which can be pre-set as required, is incorporated and the pump will automatically compensate for line variation. This ensures that as additional spray guns in the system are brought into operation, extra material is delivered to maintain the line pressure at the specified value. A six-gun system can be installed for £200, it is claimed.

Bullows-Binks "Pogo" materials handling Pump
Alfred Bullows & Sons Ltd.



The Dohm Electran transformer plug
Dohm Ltd.

Transformer plug for portable electric tools

It has been emphasized by the Chief Inspector of Factories that to ensure safety with portable electrical appliances "the problem is usually best tackled at source, that is, by reducing the voltage of the supply to the portable apparatus". The transformer plug introduced by Dohm Ltd., 167 Victoria Street, London, S.W.1, steps down the mains supply from 240V to 25V for the safe operation with trailing cables of inspection lamps, soldering irons, and small tools. Overall dimensions are only slightly larger than those of an ordinary plug, like which it can be inserted in a standard 3-pin socket, direct to the mains supply. Produced in two different capacities, 25 watt and 40 watt, it is robustly constructed and encased in oil-resistant, hard rubber.

The trailing cable carrying the full mains voltage is a continuous hazard in industry. A frayed lead, a defective or loose connection, an insulation breakdown, or even a wet floor could result in a serious, even fatal, accident. With the current stepped down to 25V by this transformer plug at the mains supply point, all danger from wet working conditions is eliminated and the cable can even be severed without the risk of shock. The plug is of special value in locations where solid, liquid, or gaseous fuels, solvents, oils, or paints are present, and in dust-laden atmospheres where sparking could involve the risk of fire or explosion.

Malleable Iron Castings

New Foundry for Shotton Bros. Limited is Arranged for Continuous Flow-line Production

MALLEABLE iron castings are produced from white iron castings by a heat-treatment process, commonly referred to as "annealing." which reduces the carbon content of the white iron. After annealing, the iron has mechanical properties approximating to those of a good quality wrought iron. There are two main types of malleable cast irons, known as "whiteheart" and "blackheart"; the terms derive from the appearance of their respective fractures. They differ in composition and in heat treatment. The white iron intended for whiteheart castings may have from 3·0 to 3·6 per cent total carbon and relatively low silicon and manganese contents, and the annealing is carried out under oxidizing conditions. In the white iron for blackheart castings there will be less total carbon, 2·2 to 2·8 per cent, and higher silicon and manganese contents. Non-oxidizing conditions are provided during annealing and consequently there is considerably less loss of carbon.

Blackheart malleable castings are widely used in the motor industry and find application for parts requiring good resistance to shock. Typical components are wheel hubs, differential cages, steering boxes, spring anchor and shackle brackets, levers, control pedals, and brake shoes. The British Standard Specification for malleable cast iron defines three grades of blackheart malleable for which the mechanical properties are as shown in the table.

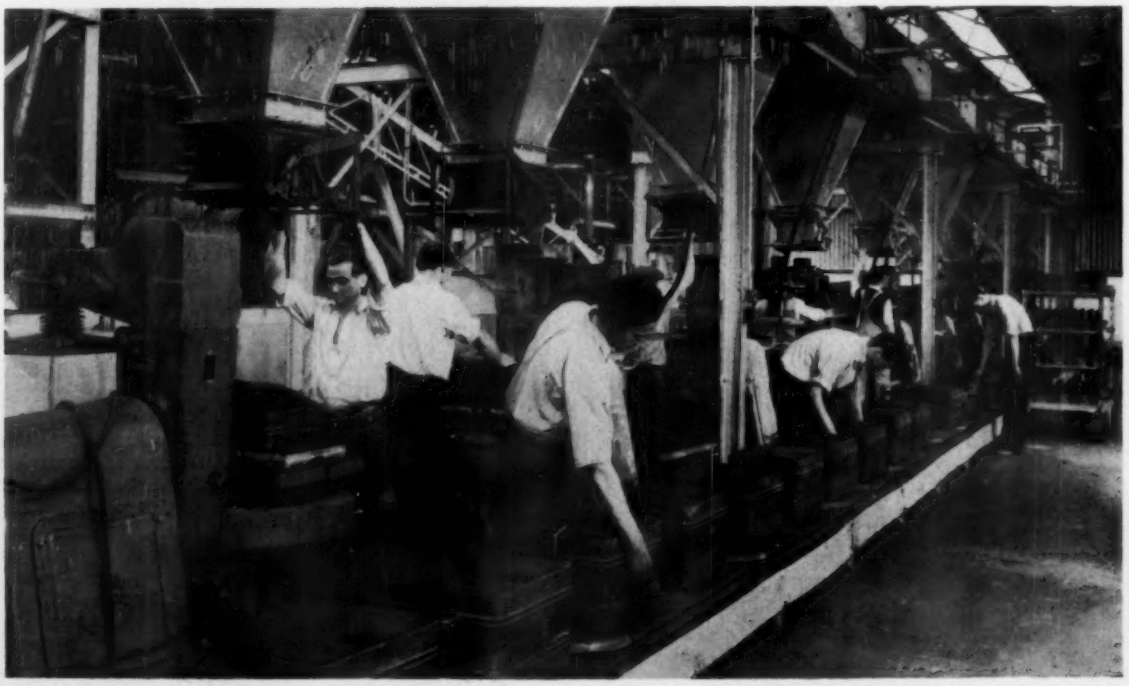
The technique of casting malleable iron differs materially from that for the ordinary grey iron, requiring different metal composition, different foundry equipment and, additionally, the long annealing process. Accordingly, the production of malleable iron castings has for long remained in the plants of specialist concerns. In general, these are long-established firms of foundrymen, possessing wide experience of the requirements of a variety of industries and an invaluable accumulation of production "know-how."

Shotton Bros. Limited, founded in Oldbury, near Birmingham, in 1894, is such a firm. Since the early days of the motor vehicle it has been a prominent supplier of blackheart castings to the motor industry. To meet modern requirements, the firm has excellent research and development facilities and is now backed by the resources of the Birfield Group, of which the firm is a member company.

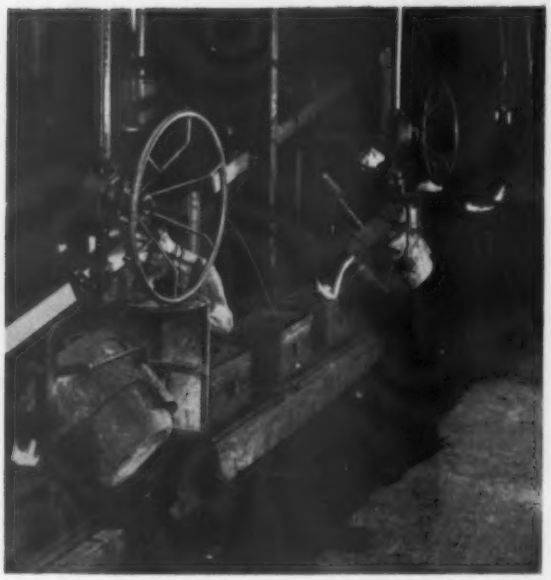
Grade	Ultimate Tensile stress Ton/in²	Elongation per cent	Yield stress Ton/in²
1	18	6	10
2	20	10	11
3	22	14	12

Arising from the need to increase productive capacity, a second foundry has been built at Halesowen and is now in full operation. It occupies about one-sixth of a 10-acre site

The moulding section of the continuously moving pallet line, alongside a battery of ten moulding machines. Cores from wheeled racks are laid from the gangway side of the line



Tapping one of the three rotary melting furnaces. Heats are staggered to ensure a continuous supply of molten metal



Pouring the moulds on the moving pallet conveyor. A shield on the the suspension gear screens the ladleman from radiated heat

and is intended as the first of a number of similar foundry units, each having a capacity of about 80 tons of castings per week. This first unit was designed and the equipment laid out so that a second unit can eventually be built alongside as a mirror-image replica and the two operated as a single plant.

The new foundry is intended primarily to give high-rate production of blackheart castings, using the minimum of pattern equipment. Work flow is arranged to reduce, so far as is practicable, material handling and other non-productive operations. The flow chart shows the movement of metal, sand and cores during the production process. Deliberately, the handling equipment has been kept as simple as possible to maintain flexibility in operation, so that the plant can, if necessary, be used to supplement the facilities of the Oldbury foundry for producing short runs of castings and castings to special requirements.

Working conditions are maintained to a high standard. Efficient fume and dust extraction equipment is installed and entrained dust is trapped to prevent its discharge into the atmosphere. The building is well ventilated and local radiant heaters are provided for static workers.

Metal control

Three Stein and Atkinson rotary, batch melting furnaces are employed, their heats being staggered in order to provide a continuous supply of molten metal of a controlled composition. Extremely narrow analytical limits are maintained to ensure the correct carbon-silicon balance and a consistent high-quality product. The carbon content, normally 2·4 per cent but varied to meet specific requirements, is held to a tolerance of less than 0·1 per cent, while the silicon content is kept within 0·04 per cent of the desired value.

Batches of raw materials, pig and scrap, are stored in separate pens and their composition is checked against the respective supplier's quoted analysis. The ingredients of a charge—pig, steel scrap, soft back-scrap, hard back-scrap, manganese, and limestone—are carefully weighed. Each rotary furnace has a capacity of 7 tons and can be tilted for charging and slag clearance. It is fired by creosote pitch, heated to 180 deg F to maintain fluidity in a storage tank outside the main building and fed to the burner at a pressure of 61·5 lb/in² by a metering pump. All air, to a controlled weight, is preheated to 350 deg C in a recuperator, in which the air flows through U-tubes over which passes the furnace flue gases at a temperature of 600-700 deg C. Primary air is supplied at 7 lb/in² and secondary air at 12 in W.G.

From each melt two samples are taken before the metal is poured. The first sample is taken and a rapid chemical analysis is made to determine the carbon, silicon and, where necessary, manganese contents. Should this analysis disclose a discrepancy in the amount of any constituent, additional metal is added to redress the balance before the second sample is taken out for analysis. During pouring, a sample is taken every 15 minutes and since a chemical analysis

Control station of one of the three Stein and Atkinson rotary furnaces which are fired with creosote pitch

The knock-out station is hooded and fumes and dust are drawn off by a side-draught extraction system

occupies only 20-25 minutes, any change in composition is quickly detected.

Should the composition of a batch of castings fall outside the specified limits, it can be rectified by an appropriate adjustment of the annealing treatment. However, to maintain a smooth flow of work through the plant it is desirable that the annealing treatment be standardized, and consequently every effort is made to keep the metal within the standard limits of composition. This is the reason for the repeated sampling of a melt. A test bar is cast from each melt for the determination of tensile strength, yield point, and elongation and to check that these values conform to the requirements of the highest grade of malleable cast iron as specified in British Standard 310. Thus each stage of the melting operation is controlled under the direction of the laboratory staff.

Moulding sand

Sand is prepared in a completely automatic plant that requires no routine supervision. Used sand returned from the knock-out station, new sand, bonding material, and carbonaceous material (pelletted pitch) are held in feed hoppers and preset electrically operated timers control the volume of each ingredient of a batch delivered on to a supply belt and into a skip. The skip discharges into a reversible chute which feeds one or other of two August-Simpson Mix-Mullers. Water is added from a supply having a constant flow rate and controlled by another electrical timer. Mulling proceeds for a predetermined period and then the discharge door opens automatically to deliver the prepared sand to a skip hoist which elevates it to a supply hopper.

Push buttons are provided to halt the sequence of operations if necessary, but their use will not upset the timing of operations in progress at the time. Sequence controls are interlocked to prevent overlap operations and a check timer, set to operate a few seconds after all the feed timers should have cut off, gives immediate warning if any timer has failed to do so. The control equipment, specially made by Field and Grant Ltd., Birmingham, is grouped on a panel located in the compressor house and is under the direct control of the laboratory staff. Routine tests on the prepared sand are carried out at half-hourly intervals. These include determination of moisture content and green strength compression, shatter and permeability tests.

Distribution of the sand is manually controlled. From the supply hopper the sand is conveyed by a belt to the individual feed hoppers located over the ten moulding machines.

Coremaking

The new sand is dried and then transferred through a pneumatic duct to a pair of totally enclosed storage hoppers. Electrical probes are provided in the hoppers to indicate when they are full and when they need replenishing. Beneath each storage hopper is a weigh hopper which discharges into a mixing machine. Core oils are normally purchased ready-mixed but special mixes are made up to meet particular requirements. From the mixing machine the sand is delivered to a battery of coreblowing machines and the green cores are carried on a pendulum conveyor to the oil-fired, thermostatically controlled drying oven. On leaving the drying oven the cores are placed on portable stillages and transferred to a position adjacent to the mould conveyor until required.

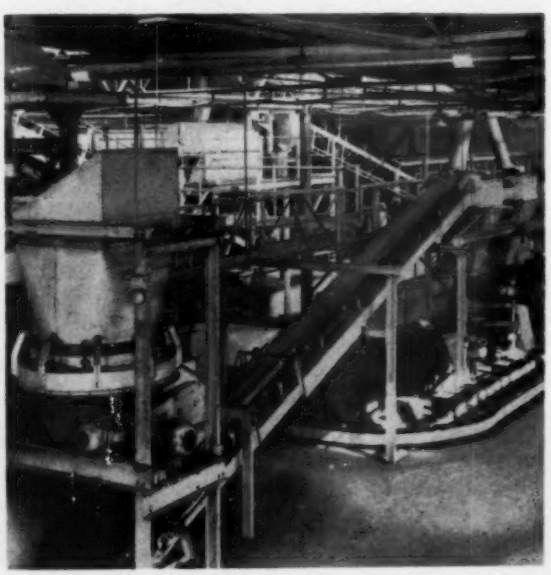
Moulding and pouring

Ten moulding machines of the jolt, squeeze, turnover, and vibrating-draw type, by the British Moulding Machine Co. Ltd., are used; four for drag moulds, four for cope moulds, and two are available for pattern-changing and sampling procedures. The drag moulds are loaded on to the continuously moving pallet-type mould conveyor and the cores are laid in from the gangway side of the conveyor. Cope moulds are then added and the complete mould then travels round to the pouring area adjacent to the melting furnaces. Metal is carried from the furnaces in Lockerbie and Wilkinson preheated ladles suspended from an overhead runway and the metal is poured in the moving mould. The operator is screened by a rectangular shield on the ladle suspension and a small shield is also provided over the tilt-lever handle.

The mould conveyor normally moves at a rate of about 10 ft/min and the mould takes approximately 30 minutes to traverse the looped cooling tunnel. This period is adequate to cool the heaviest castings that the line is expected to handle. The tunnel is completely enclosed and all fumes from the moulds are extracted by fans and discharged outside the building.

Immediately after leaving the cooling tunnel the mould arrives at the knock-out station. Here it is automatically transferred to a vibrating grid and the conveyor continues

From the sand conditioning plant a belt conveyor distributes the sand to the feed hoppers of the moulding machines



underneath the station and returns to the moulding line. Three operators are employed at the knock-out. One lifts out the cope flask and places it on a gravity roller track for return to the moulding machines, the second drags out the cluster of castings with tongs and drops it into a pallet truck, and the third lifts out and returns the drag flask. The station is completely hooded and fumes and dust are drawn off by fan to ensure a clean working area. A lateral draught is arranged and the rate at which air is drawn through the hood is carefully controlled so that sand is not lifted off the grid. As mentioned earlier, a wet dust extractor is installed to prevent atmosphere pollution. The sand emptied from the flasks falls through the grid on to a belt conveyor. It passes beneath a magnetic separator which removes particles of metal, and through a rotary screen which extracts any hard lumps of sand. Finally it is conveyed to the used sand feed hopper at the sand plant.

The pallet mould conveyor can be stopped by push button at either the moulding area or the pouring area. As a safety measure the controls are interlocked so that the conveyor can be restarted only from the control point at which it was stopped.

Annealing

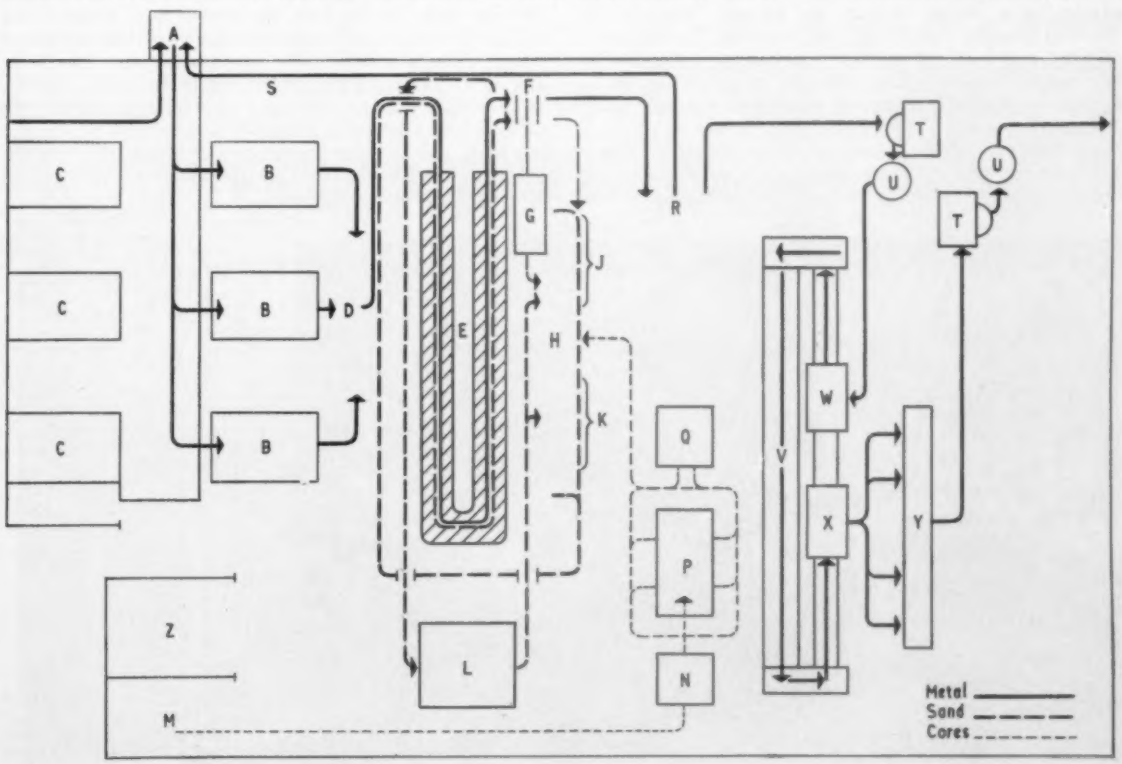
After runners, risers, and feeder heads have been knocked off, the so-called "hard" castings are transferred by lift truck to a rotating table, shot-blasting machine for cleaning. From this machine they are off-loaded to a large turntable serving as a temporary storage rack and inspection bench. Back-scrap is returned by truck and lift to the furnace charging platform for remelting. Inspected castings are placed in boxes and passed down a roller track to the packing station alongside the annealing furnace.

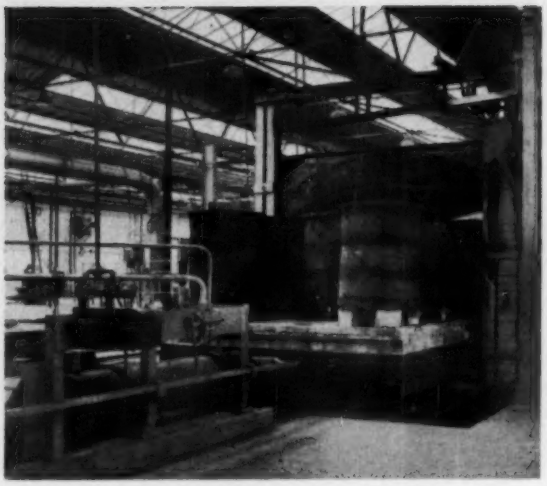
Before being passed to the annealing furnace, all castings are shot-blasted and undergo an individual inspection

Here the castings are stacked carefully, to minimize warping in the furnace, in cylindrical, white iron containers and sealed to protect them from the combustion gases during their passage through the furnace. Six containers are mounted on a heavy rail truck, which is winched to the intake end of the furnace, laterally transferred into alignment with the furnace track and, when the door has been opened, pushed into the furnace by a hydraulic ram. This progresses

Flow chart of malleable iron foundry

A *lift to furnace charging platform;* **B** *rotary melting furnaces;* **C** *recuperators;* **D** *pouring line;* **E** *cooling tunnel;* **F** *knock-out station;* **G** *moulding boxes;* **H** *moulding machines;* **J** *moulding drags;* **K** *moulding copes;* **L** *moulding sand plant;* **M** *core sand store and dryer;* **N** *core sand mixer;* **P** *core blowers;* **Q** *core oven;* **R** *cooling area for castings;* **S** *back-scrap;* **T** *shot-blast;* **U** *inspection;* **V** *annealing furnace;* **W** *packing station;* **X** *unpacking station;* **Y** *fettling;* **Z** *pattern and maintenance shop*





A truck-load of castings, sealed in white iron containers, is pushed by hydraulic ram into the annealing furnace

Setting the fettled castings before final shot-blasting. Some work is flattened or trued on a Taylor and Challen press

the whole train of trucks already in the furnace and a truck-load of annealed castings is simultaneously discharged from the other end. The furnace is operated continuously and a loaded truck enters at intervals of eight hours. In the course of a working week a stock of castings is accumulated sufficient to keep the furnace fully loaded over the succeeding week-end.

Annealing is carried out at a temperature of 900 deg C and the duration of the treatment may be varied according to the size of the castings. The initial or preheating period is to obtain an even temperature throughout the casting, and the cooling process is performed very slowly and is necessarily of long duration. From five to six days will be taken in the passage of a casting through the furnace. Supplied by Nu-Way Heating Plants Ltd., of Droitwich, the furnace is oil-fired and both oil and air supplies are controlled by electrically operated valves. In each of four zones in the furnace the temperature can be selected at will and can be controlled to within ± 5 deg F. Thus, the annealing cycle for a particular batch of castings can be adjusted to meet special requirements. Kent recorders keep a continuous record of temperatures so that the exact annealing cycle of each batch of castings passed through the furnace can be readily computed.

Fettling and setting

On leaving the annealing furnace the castings are unpacked and placed in boxes for transfer over a roller track to the fettling lines for the removal of gates and flashings. There are two parallel lines of grinders; the heavy line equipped with Luke and Spencer duplex grinders and the light line having Canning duplex high-speed spindles with narrow wheels for grinding awkward locations. Each grinder is connected to a wet-blast extraction system.

The dressed castings are then passed to the adjacent "setting" area. In the main this implies hand straightening and the proving or rectification of shape by driving in internal forms. Flanges and flat work are trued between platens or dies on a Taylor and Challen friction screw press. Finally, the castings are passed through a second Tilghman rotating table, shot-blasting machine. Every casting is visually inspected before removal to the dispatch department. At random, individual castings are taken out and broken up to check their internal solidity.

Fettling the annealed castings on a line of Luke and Spencer duplex grinders. In the background is the annealing furnace

THE HANCOCK TELECONTROL

An Electromechanical, Visual-Record, Control System to Eliminate Paper-work at all Production Supervisory Levels

IN this new production control system each item of productive equipment in the workshop is linked electrically to a central monitoring room. There, on separate panels for each machine, up-to-the-minute production data is continuously displayed in visual form for the use of production control personnel. The system cuts out the need for time-consuming paper-work at all supervisory levels. Particularly, but not exclusively, intended for mass production plants, Hancock Telecontrol equipment, manufactured by Control Systems Company, a division of Hancock Industries Inc., Michigan, U.S.A., can monitor and control the production process, step-by-step, throughout each working shift. At any time the management can ascertain visually, or by report from a supervisor, how production is progressing, on what equipment and at what expenditure of labour time. Incoming production data is recorded on counting devices for subsequent use. Emergencies in the workshop, relating to stock, materials, tools or machines and requiring immediate attention, are notified directly to the supervisors. The supervisors in the monitoring room can call-up the foreman, stock men or maintenance men on a public-address system and then instruct directly by telephone.

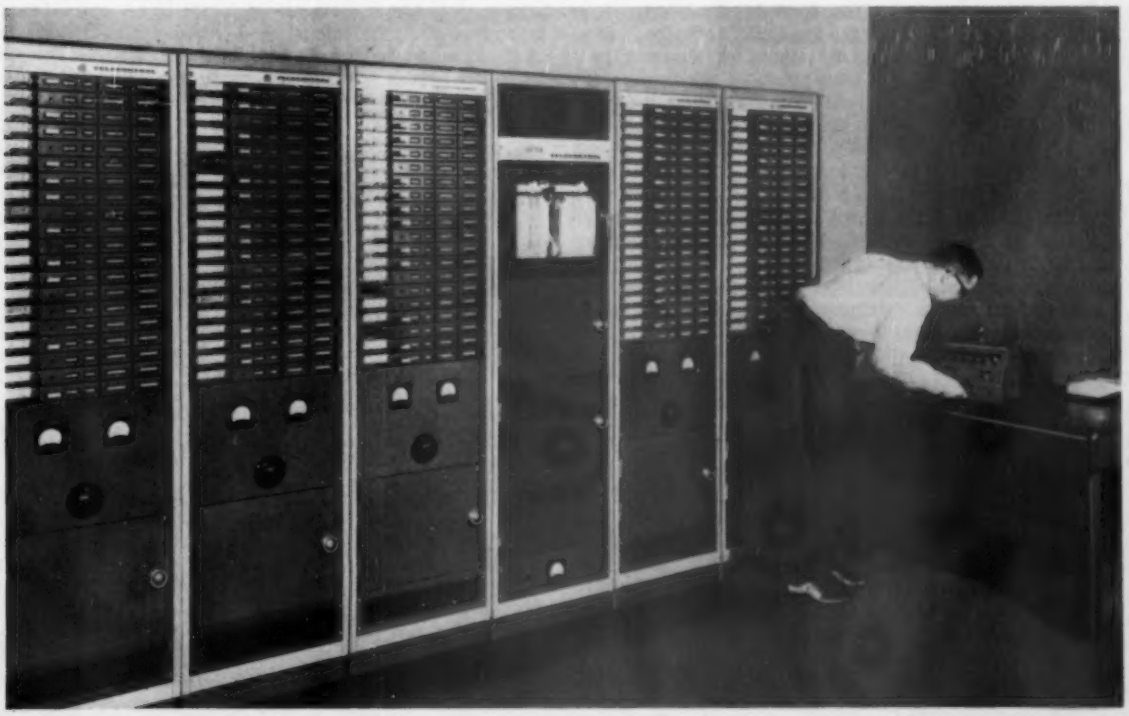
A Telecontrol installation requires a single monitor cabinet and a number of control cabinets, each of which can accommodate twenty production machine circuits and display panels. Up to ten control cabinets can be operated in conjunction with one monitor cabinet. Where more than 200 production units are to be integrated further monitor and control cabinets will be required.

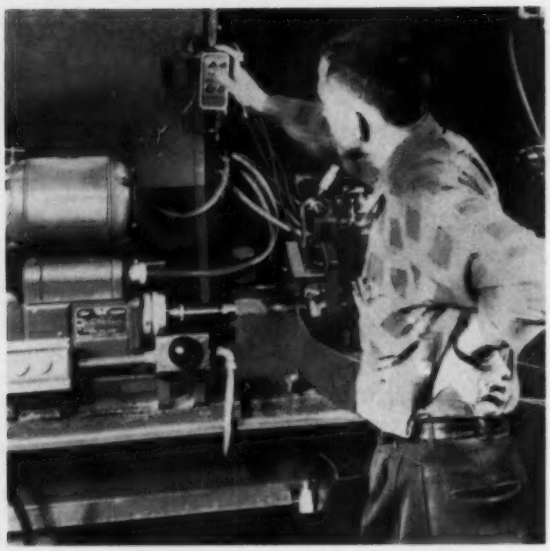
Each machine or sub-assembly line is equipped with a control box that provides the machine operator with a means of signalling the monitoring room. This box has two lights, an alarm switch, a reset button, a lock, and a telephone socket. Both lights are duplicated on the appropriate display panel on one of the control cabinets. During normal production, only the green light shows but when the operator needs help from his foreman, he signals by pushing the alarm switch and the red light starts to flash in the monitoring room. At the same time an intermittent audible signal attracts the attention of the supervisor and warns him to direct the foreman over the public-address system to the machine station requiring assistance.

The foreman arrives and diagnoses the trouble. If the operator requires more parts or materials for his machine or finished work to be taken away, the foreman will plug a special telephone handset, which he always carries, into the control box and ask the supervisor to send the stock man. Thus, no operator needs to lose any production time by ceasing work and leaving his machine.

Should the trouble be mechanical and require repair, the foreman makes a request to the supervisor for a maintenance man to be sent. He is summoned over the public

In the monitoring room the supervisor calls a foreman over the public-address system and directs him to a machine station requiring attention





When a machine operator, for any reason, requires assistance he notifies the supervisor by depressing the alarm switch

address system. When he arrives, the foreman may then transfer the operator from a productive rate to a downtime rate by inserting a key into the control box. This key, which only the foreman carries, turns the red light on continuously both at the box on the machine and the display panel in the monitoring room. This arrangement enables the supervisor to see at a glance whether a machine is inoperative and the worker on downtime rate. If the repair is likely to occupy a considerable peroid of time, the foreman will assign the operator to another machine already set-up for production. Thus, unproductive time on the part of the operator is kept to a minimum.

Each display panel on the control cabinet carries in addition to the red and green lights, four electromechanical registers. These devices present respectively the productive time, downtime, number of parts produced during the shift, and the balance of the unfinished order. As long as the green light is on, the productive time register shows the time elapsed, the parts register indicates the pieces produced, and the balance register subtracts an equal number of parts. Whenever the foreman turns his key and the red light goes on, the productive time register stops and downtime is indicated on the unproductive time register in fractions of hours. As soon as the balance register is zeroed, indicating the required number of parts has been made, the green light begins to flash and an intermittent audible signal warns the supervisor that the order is complete.

Since each operator is linked to the monitoring room through his control box, the production management is continuously informed how every machine in the shop is functioning. In addition, the public address system and the special telephone link the shop supervisory staff throughout the plant to the central monitoring room and to each other. The foreman, apart from having to assign operators to machines before the shift starts, has no paper-work to do or records to keep and can concentrate his time and efforts on supervising the operators.

The display panel for a machine will not function until the supervisor inserts a small plug marked with the operator's number, signifying the machine is now manned. As the shift starts, a master time clock in the plant closes the circuit and actuates the entire Telecontrol system. The green lights are switched on at the display panels and also at the control boxes on the machines, informing operators that they may begin production.

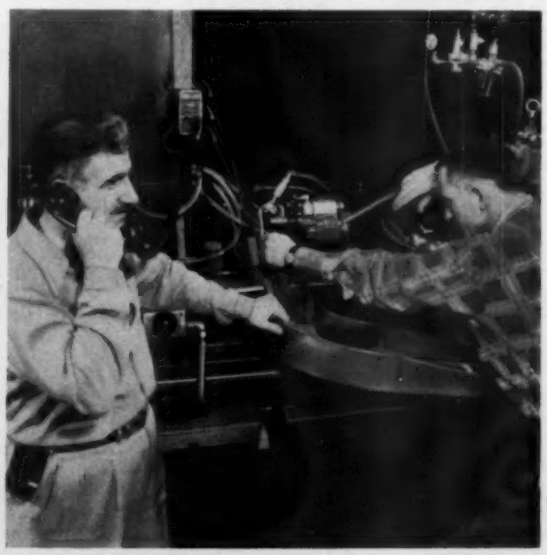
At the end of each shift, the supervisors transfer all production statistics to a five-channel tape add-punch machine so that other departments, such as accounting, planning, purchasing, production, and engineering, may immediately compute their requirements and the day's production data from the punched tape.

No degree of automation will increase the efficiency of a plant or result in true mass-production if the manufacturing management is not continuously informed regarding current conditions within the plant. The Telecontrol system avoids the need for extensive plant tours and brings production control directly to each machine. The system acts, in effect, as an automatic work-registration unit that keeps close checks not only on costs, but also on rates of production. It provides a clear, visual record of each operator's productive and unproductive time and each machine's productive status. Every machine in the plant can be linked by both intercommunication and telephone to save time in reporting trouble.

The first and experimental Telecontrol system has now been in full operation for over a year, and has monitored and controlled production of automobile parts on 200 machines at the Hancock Manufacturing Company, Jackson, Michigan. The installation has reduced costs by nearly $100,000. No less than $80,000 was saved in non-productive payroll, as the sixteen men formerly required were transferred to other functions and the monitoring room is now manned by two supervisors. More than $20,000 was saved in one year by the reduction of downtime, which was turned into additional productive labour.

With two hundred machines connected to a Telecontrol, cost per machine controlled is in the region of $250. Thus, it will be apparent, the capital investment was recouped in about six months operation. For a lesser number of machines to be integrated into a control system, the cost per machine will, of course, be slightly higher. Owing to the inherent simplicity of the electromechanical design, Telecontrol equipment can be serviced and repaired by the plant maintenance staff.

The foreman diagnoses any trouble, plugs in a portable telephone hand-set and confers with the supervisor regarding necessary action



Where parts are to be mass-produced in a series of repetitive operations, the system finds ideal application. It reduces costly downtime and raises productivity at a lower total overhead cost. Apart from providing visible records of such vital statistics as labour time and productive effort, the entire production sequence is presented at a single, central position where it can easily be supervised and controlled. Any emergency arising in shop production can be immediately brought to the notice of the supervisors.

Shift Operation

Overall production plans, co-ordinated between the top management and sales, engineering, purchasing and production departments, are frequently drawn up weeks before the work order is issued. Resulting daily production instructions and schedules are sorted in the monitoring room in accordance with job priorities. The overall manufacturing plan and individual work schedule for each separate job is ticketed and placed on to a separate display unit identified by the number of a machine in the shop. Each display panel has a green "normal" light, a red "warning" light, and a detailed production job card that tells the job number, part number and operation, labour rate, quantity and type of material. A copy of this job card is sent to the production machine for set-up purposes. The display unit also contains an operator's numbered plug. When inserted, this plug indicates the operator has been assigned to the particular machine. Insertion of the plug closes the electrical circuit.

Before the shift starts, the supervisor determines what orders are to be produced during that shift. As he assigns the various jobs to the machines, he sets the balance counters at the total number of parts required. When individual jobs have been set-up on the control panels, the foreman assigns an operator to each machine. Thus, it is the supervisor in the monitoring room who, in effect, has complete responsibility and authority over assignment of jobs to machines. The foreman needs only to assign the operators to the machines required for that shift's production run.

As the shift starts, the plant's master time-clock completes the Telecontrol circuit. Wherever an operator's plug is inserted into the display unit, the green lamp comes on, indicating that the machine is on productive status and being manned. At the same time, the control box on the machine also lights green, authorizing the operator to proceed.

Most machines and production stations in the plant are equipped to count the parts produced. This counting may be accomplished in a number of ways, selected according to the function and design of the production equipment. Limit switches, photo-electric cells, mechanical gates, or other devices are used, depending on whether measurement is made of rotating or reciprocating motion. As each piece is produced, the sensing device pulses an electrical signal to the display panel in the monitoring room. The counter acts in effect as a simple electromechanical tally of pieces produced during the shift. During actual operation, the productive time is registered on another counter in units of 0·01 hour (36 seconds).

Individual display units representing machines or production elements within the plant contain all the necessary information for the accounting department, such as payroll, cost, and production data. Because information is given to the accounting department from one central source, where it is gathered from easily read display panels instead of from masses of paper-work, chances of errors occurring are much reduced. Furthermore, the time taken to pass on this information to the accounting department is minimized.

Since complete information is presented on each display panel, data may be recorded by different methods to suit any data-processing system currently in use. Whether manual or machine book-keeping methods are used, or with punched-card or more advanced electronic processing systems, data may be tabulated under the following heads:

Machine number	Piece-rate time
Job number	Downtime
Job rate and allowance	Parts produced and unfinished balance of parts

Other related information can be made available in master cards or in punched-tape form.

Particularly suited to industries where manufacturing costs and rates must be made available to management during and not after production, the Hancock Telecontrol system provides a simple, economical, and yet versatile means of monitoring and controlling manufacturing activities. The equipment is adaptable to fully automated plants or to mass-production at varying manufacturing speeds. It is capable of making 36,000 recordings per hour, but can also count at rates as low as one part per hour in special applications.

Each machine has a display panel on the control cabinet. A panel becomes "live" when the operator's plug is inserted

PEDAL CAPS

A RANGE of caps for brake, clutch and throttle pedals has recently been introduced by L. B. Plastics Ltd., of Broadholme, Belper, Derbyshire. An interesting feature of these caps, in view of the current trend towards the brightening of body interiors, is that they are available in a range of colours. The material of which they are made is polyvinyl chloride, which has advantages from the point of view of resistance to abrasion, certain solvents, and mineral oils.

ALL-STABILO PENCIL

A NEW type of black lead pencil, which will write on plastics, china, glass and all glazed surfaces, is being marketed by The Plastic Packaging Division of Gordon and Gotch Ltd., of 75, Farringdon Street, London E.C.4. The writing is clear and dense, non-dusting and waterproof. It can be removed from paper with a pencil eraser, and from other surfaces with a damp cloth. The pencil is more economical in use than the softer wax type, since it requires less frequent resharpening.

THE ROBAR DIE-CASTING MACHINE

Production of Hollow Components Without the Use of Cores

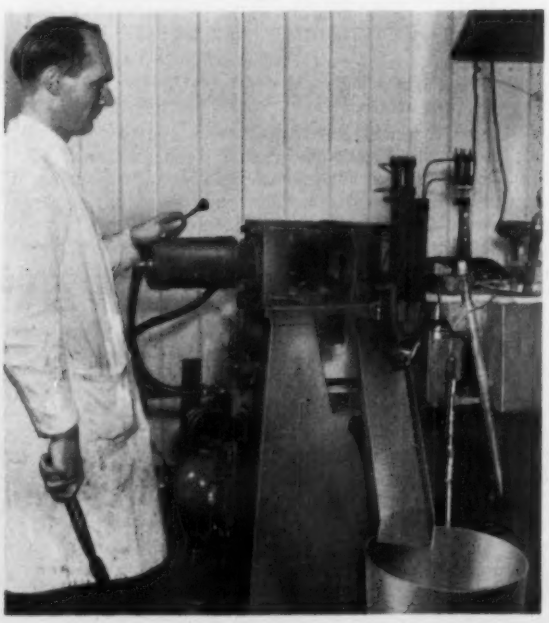
SUPERFICIALLY, this machine resembles a conventional pressure die-casting machine and, in fact, can be used as such for the production of solid articles. It was, however, specifically designed for the production of hollow articles without the need to use a central core in the die. The inventor of the process is J. D. Guest and the machines are being developed and built by Robar Products (London) Ltd., 39 Park Street, London, W.1. The prototype machine illustrated is already employed on commercial mass production.

In basic principle, the process may be regarded as following the centuries-old practice of the makers of hollow lead castings for toys and religious symbols, but performed under pressure instead of dependence upon gravity. In the old method the molten metal was poured into a cool divided die (usually held in tongs), the metal in contact with the die rapidly solidified to form a shell, the die was inverted, and the still fluid central mass of the metal poured out.

On the Robar machine the die cavity is evacuated to create a negative pressure and thus ensure complete filling with metal, the die is maintained at a predetermined low temperature, the molten metal is forced in by a ram, is held under pressure for a predetermined period to form a shell, and the ram is withdrawn to draw out the still molten metal from within the shell. All these operations can be precisely controlled with modern equipment.

With suitable die design, temperature regulation and timing, the thickness of the shell can be controlled as desired down to 0·020 in and held within a tolerance of ±0·005 in. There is virtually no limit to the size of the article cast other than the capacity of the machine. Indeed, the larger the article the simpler it is to evacuate the molten metal. Machines can be arranged for semi-automatic or full automatic cycling and control.

Prototype Robar pressure die-casting machine producing hollow articles without the use of a central core. In this view the die platens have opened and the ejected casting is being chuted to a bin



The machine can be operated at any of the usual temperatures for pressure die-casting but, as already noted, it is desirable for the die to be run cooler than is normal. The die temperature commonly employed is approximately 180 deg F. This yields a number of important advantages. It shortens the operational cycle and thus makes possible a higher rate of production. A complete cycle extends only from 3 sec to 10 sec, even for large articles.

Due to the shortness of the "dwell" period the corrosive effect of the hot metal on the die is sensibly lessened. It follows that the die steel need not, therefore, be of such a high quality as that normally used. Since the die is run at well below the critical temper heat of the steel, it will retain its hardness and have a longer useful life. A subsidiary advantage of this aspect is that flash on the article produced will be less.

The rapidity of the injection is such that the metal is forced into the die with but little loss of heat. As the temperature of the die is precisely controlled and the air in the cavity has been exhausted, the surface of the casting is of an exceptionally dense structure, which is highly suitable for plating.

Operational cycle

To achieve sound structure, uniform wall thickness, and a consistent extraction rate of the molten metal from the casting, the machine's functions need to be closely controlled and precisely timed. The cycle of operations follows:

1. Die platens are closed
2. Die projections go home. These are not invariably necessary but are required if the shell is to be apertured
3. Negative pressure is created in the die cavity
4. Ram forces molten metal into die cavity
5. Period of "dwell" to allow shell to solidify
6. Withdrawal of ram, evacuating molten metal from the interior of the shell
7. Molten metal above the ram replenished by fresh metal ready for the next shot
8. Die projections are withdrawn
9. Platens are opened
10. Casting is ejected in conventional manner.

Control cabinet

Control can be arranged on any convenient system, pneumatic, hydraulic, electric, or electronic. All controls are grouped in a cabinet separate from the machine and requiring a minimum of connections. Pneumatic control was selected for the prototype unit illustrated, as all necessary valves, switches and timers were readily procurable and control could be established by connection to normal services and the shop air line. Several machines, either semi-automatic or fully automatic, can be controlled from a single cabinet.

A cabinet houses five banks of controls, four of which are fully adjustable. These control the sequence of operations

and the timing of each operation individually and also in relation to other operations which may be carried out simultaneously on the machine. In the base of the cabinet is accommodated the motor-driven, vane-type, rotary exhauster used for creating the negative pressure in the die cavity prior to injection.

Bank A controls the movement, speed, and dwell of the injection ram, on both the injection stroke and the evacuation stroke. The main function of Bank B is to control the movement, speed, and dwell of the toggle action for closing and opening the die platens. It also provides the interlocks by which all operations are arrested should the platens fail to close fully. The movement and speed of any die projections that may be necessary are controlled by bank C. These projections, or side cores, can exercise two functions. They can produce holes in the shell where required and can accommodate passages through which air in the cavity is exhausted before injection and air at atmospheric pressure is admitted to the interior of the casting when the injection ram withdraws, thus assisting evacuation.

Bank D, where required, controls the creation of negative pressure in the die cavity prior to the injection of the metal. A negative pressure, in addition to assisting the filling of the cavity with metal, can effect an improvement in the quality of the casting, and particularly of the surface finish. Bank E controls the weight of metal passed into the cylinder prior to the injection stroke of the ram and also prevents metal passing from the melting pot into the cylinder and the die on the evacuation stroke.

Production economies

When compared with conventional machines and methods it would appear that the machine and the process offer substantial economies in production. Owing to the absence of cores, the dies will be less complicated and consequently the time required for making, and the cost, will obviously be much reduced. The cost of core maintenance, which can be an expensive item if the cores have a high fineness ratio, is eliminated. Extraction rate, that is the proportion of metal withdrawn from an otherwise solid casting, will vary according to the type of casting but is higher than is attainable with a cored casting and is usually of the order of 50 per cent. It follows there will be a lessened expenditure on metal and also that component weight will be reduced.

An air-operated unit controlling and timing the complete cycle of machine operations. A single unit can provide automatic or semi-automatic control for several machines

Inherently, the process is a rapid one. The cycle must be of short duration in order to avoid loss of heat and consequently to maintain the desired extraction rate, and also to ensure fluidity of the metal evacuated through passages that may be long and of small cross-sectional area. Rate of production will, therefore, be high and give better machine and space utilization.

The prototype machine is relatively small and can produce castings up to approximately 4 in long × 1¼ in diameter. However, no difficulty is foreseen in building much larger machines for the production of larger castings. An obvious application for the motor industry would seem to be such items as door handles and hollow body trim. It is suggested that with further development light alloy cylinder heads for watercooled engines could be produced.

A development of some interest, at present under investigation, is the production of hollow magnesium castings in low-cost dies of Mazak.

BATCH COUNTER AND TIMER

INFORMATION concerning a new high-speed dekatron batch counter and timer has recently been made available. The unit is manufactured by Elcontrol Ltd., of Wilbury Way, Hitchin, Hertfordshire. Although a prototype of the unit was shown at the Automation Exhibition in 1957, a great deal of development work has been done on it since then.

The unit, which is of the fully electronic type, makes use of up to four dekatron stages, and the total count is displayed on the dekatrons. It embodies its own pulse-shaping circuits and will accept normal external pulses, including those of photo-electric origin. The counter can be arranged to generate its own pulses, and therefore can be used as a timer.

As a batch counter, it can be automatically reset, the minimum period between batches being about 1/5th sec. It can also be reset on operation of external contacts, or on a specified count of successive batches. Successive batches alternately energize and de-energize relays.

When the unit is used as a timer, a 100 c/sec signal is provided by it. With the batching facilities already described, the following timer functions are available. It can be used as a cyclic timer, with a 1/5th sec fixed dwell; as a process timer with external initiations; as a cyclic timer with a prefixed dwell period; or with equal times on both 'on' and 'dwell'. The unit can also be used as a time measurer, recording between successive operations of external contacts. Its accuracy is that of the external mains frequency, and its resolution is ±10 milliseconds.

The performance specification is as follows. A maximum counting rate of 500 counts per second is obtainable. The minimum recovery time between batches is 3 milliseconds. Its relay contacts are 1 HD c/o, 1 LD n/o, and 1 LD n/o, and the count capacity is 9,999.

So far as construction is concerned, the unit is made up as follows. Four decade units, together with the photo-amplifier circuit, are assembled on individual chassis, which can be separately unplugged from the complete rack. The power pack and trigger unit are independently assembled on a complete chassis housed on the main deck of the assembly. For servicing purposes, the complete rack, embodying the electronic circuits, can be readily withdrawn from the case.

CURRENT PATENTS

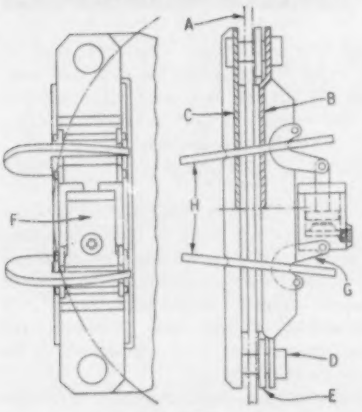
A REVIEW OF RECENT AUTOMOBILE SPECIFICATIONS

Disc brake

On this brake the hydraulic actuation cylinder is suspended between pairs of bell-crank levers pivotally connected to the shoe. It is, therefore, out of direct contact with the shoe and is not affected by the transmission of heat developed when braking.

The diagram shows brake disc A, rotatable with the road wheel, adapted to be engaged over a segment of its periphery by flat brake shoes B and C faced with friction material. The shoes are axially displaceable on pins D mounted on brake plate E secured to the axle. Hydraulic cylinder F is pivotally connected to the ends of superimposed bell-crank levers G pivoting on shoe B, and the piston is similarly connected to the shoe by a second pair of levers. A pair of flat plate yokes H span the levers and the brake shoes.

When pressure fluid is admitted to

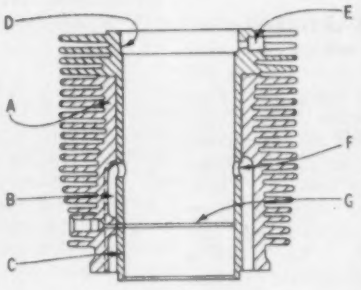


No. 778094

cylinder F, cylinder and piston are displaced in opposite directions and the movement is transmitted through the levers and yokes to brake shoe C which is brought into contact with the brake disc. Thereafter, continued movement causes the levers to pivot about the inner edges of the yokes and bring shoe B into contact with the disc. *Patent No.* 778094. *H. Teves and A. E. Teves (Germany).*

Air-cooled cylinder construction

In the quest for efficiency and weight-reduction, an air-cooled cylinder for a two-stroke engine of the fuel injection type is made of light alloy and fitted with a liner of cast iron. Difficulties are likely to be encountered, however, owing to the different rates of expansion of the two metals and the likelihood of unsymmetrical thermal stressing. Variation of temperature is likely to be most marked in a zone immediately below the cylinder head joint face. It has been proposed to furnish the upper end of the liner with cooling fins so that the finned part replaces the cylinder at its region of highest stress. The transition face between cast iron cylinder and light alloy cylinder head then becomes the relatively weak point, owing to the greater expansion of the head.



No. 786952

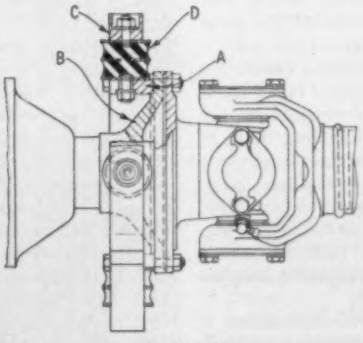
It is the object of the invention to circumvent this difficulty. The light alloy cylinder A is formed with passages B for the transfer of the air charge from the crankcase to the cylinder in the usual manner. Pressed into the cylinder is a cast iron liner C having a finned upper end which is extended, beyond the limit of the bore swept by the piston, to define at D the side wall of the combustion chamber. A light alloy cylinder head is spigoted into the combustion chamber.

A bore E for the fuel injection nozzle is arranged in the finned head of the liner. At a lower level the liner is apertured by air inlet ports F and, possibly, exhaust ports. Lubricating oil is fed to the liner bore by way of a radial drilling in the cylinder communicating with an annular groove G. *Patent No.* 786952. *Andreas Stihl (Germany).*

Torsional vibration damper

In some heavy goods and passenger vehicles a pronounced transmission noise is present under certain operating conditions. This is thought to be due to resonant torsional vibration in the propeller shaft, causing the meshing pinions in the gearbox to hammer. The damper aims at reducing or eliminating this disadvantage. It comprises an annular hub member A, registered and bolted to the gearshaft flange B, and a co-axial, ring-like inertia member C. These two members are spaced by four, preformed, vibration-damping units D, each consisting of two rubber discs sandwiched and bonded to metal end plates and a metal interleaf.

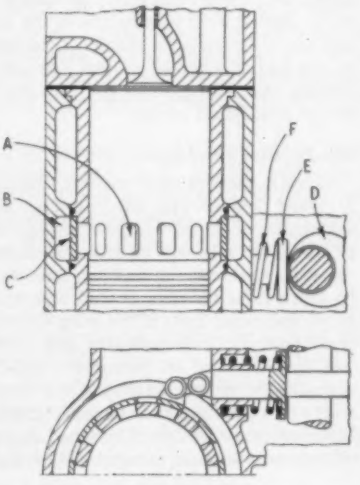
Units D are bolted to member C and then compressed to enable member A, suitably slotted, to be introduced axially. When fitted on the vehicle, it is possible to remove and replace the damping units without disconnecting the transmission or removing any other component. The metal interleaf between the rubber discs increases the radial stiffness of the unit and raises the permissible whirling speed. If desired, the interleaf may be extended to project beyond the rubber discs to provide for heat dissipation from the unit. *Patent No.* 786789. *Metalastik Ltd.*



No. 786789

Four-stroke engine

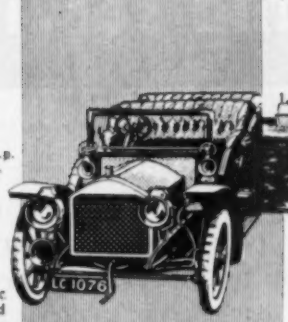
It is a known practice to arrange the valve timing of a four-stroke engine so that the effective length of the compression stroke is less than that of the suction stroke. Difficulties arise, however, in applying the practice to an engine having an exhaust valve in the cylinder head and piston-controlled inlet ports in the cylinder wall adjacent the bottom dead centre position of the piston.



No. 786969

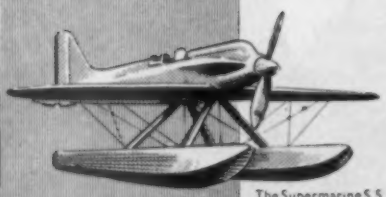
The invention proposes the use of an annular slide closely surrounding the cylinder wall and apertured to correspond with the cylinder ports. Angular displacement of the slide is controlled so that the ports are open during the early part of the compression stroke.

In the example the exhaust valve in the head is controlled in conventional manner. The cylinder liner is furnished, above the bottom dead centre position of the piston, with inlet ports A leading to an annular passage B in the cylinder jacket. An annular slide C, disposed in a groove in the wall of the liner, is angularly displaceable under the control of a cam D running at half crankshaft speed. The cam actuates a tappet E connected by a link to a lug on slide C. A helical spring F tends to hold the slide C in the closed position. Timing is arranged so that the slide C leaves the ports open during the compression stroke of the piston over a part or the whole of the height of the ports in order to shorten the effective compression stroke. *Patent No.* 786969. *Lanova A. G. (Switzerland).*



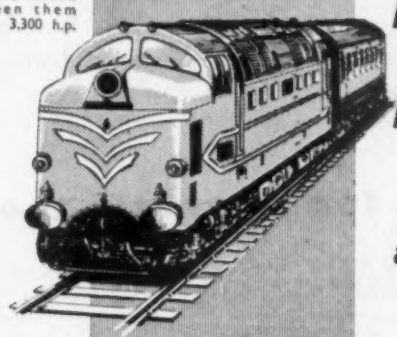
A six-cylinder 30 h.p. Napier car of 1905.

H.M.S. Highburton one of the Royal Navy's inshore Minesweepers, is powered by two Napier Deltic eighteen-cylinder high-speed diesel engines, developing 2,500 h.p. each.



The Supermarine S.5 Napier Lion-powered Schneider Trophy winner 1927. The engine was a geared Napier Lion VIIB.

The English Electric Deltic is powered by two eighteen-cylinder Napier Deltic rail traction engines, which between them develop 3,300 h.p.



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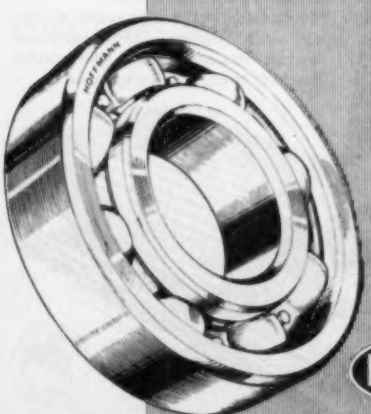

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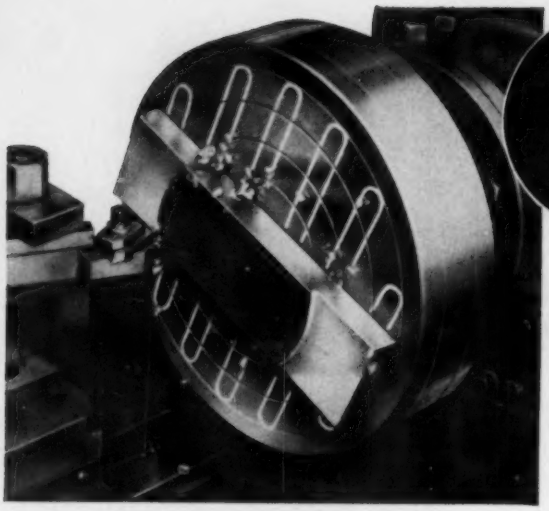

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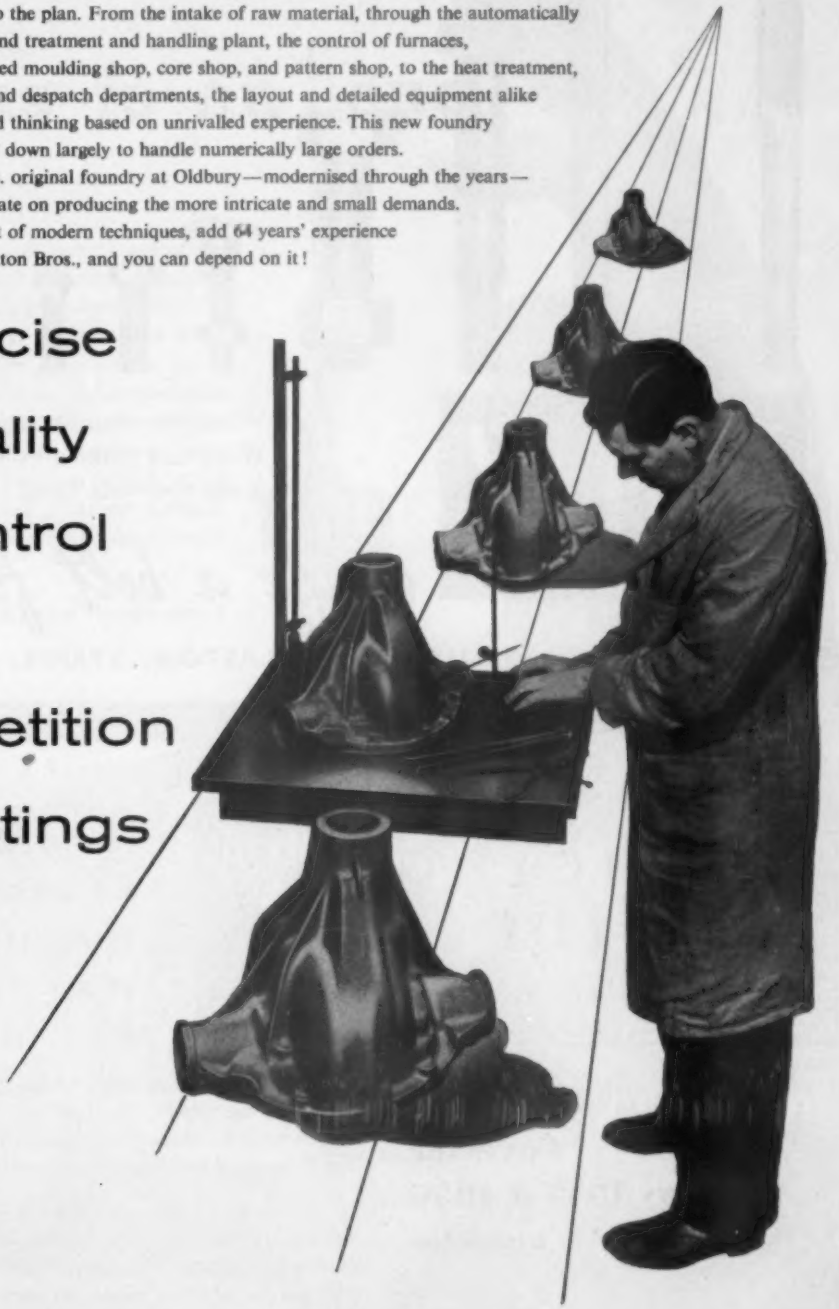

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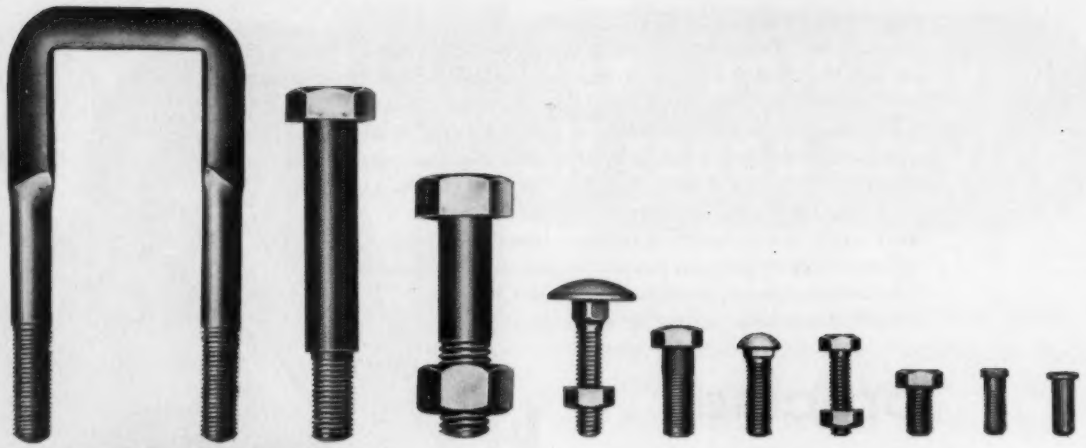

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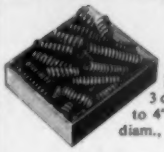

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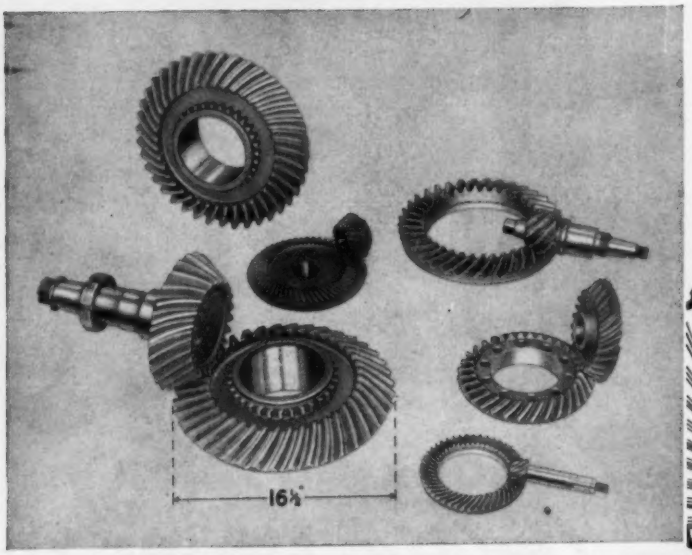

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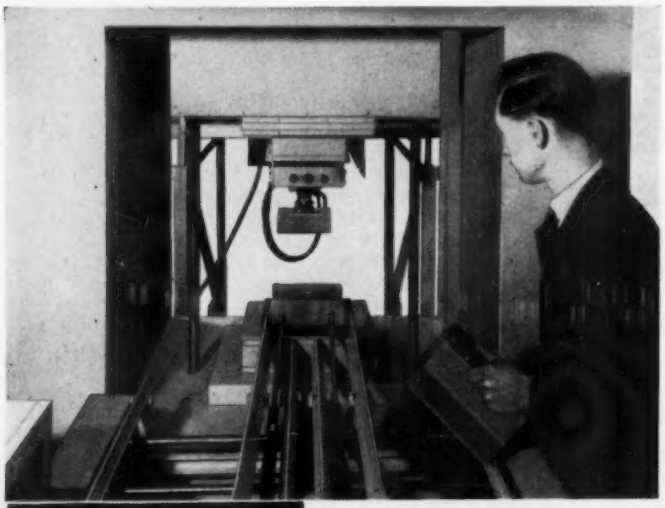

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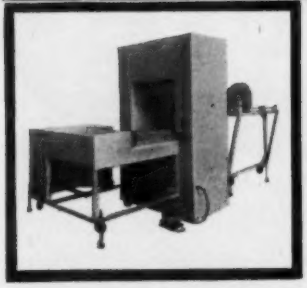

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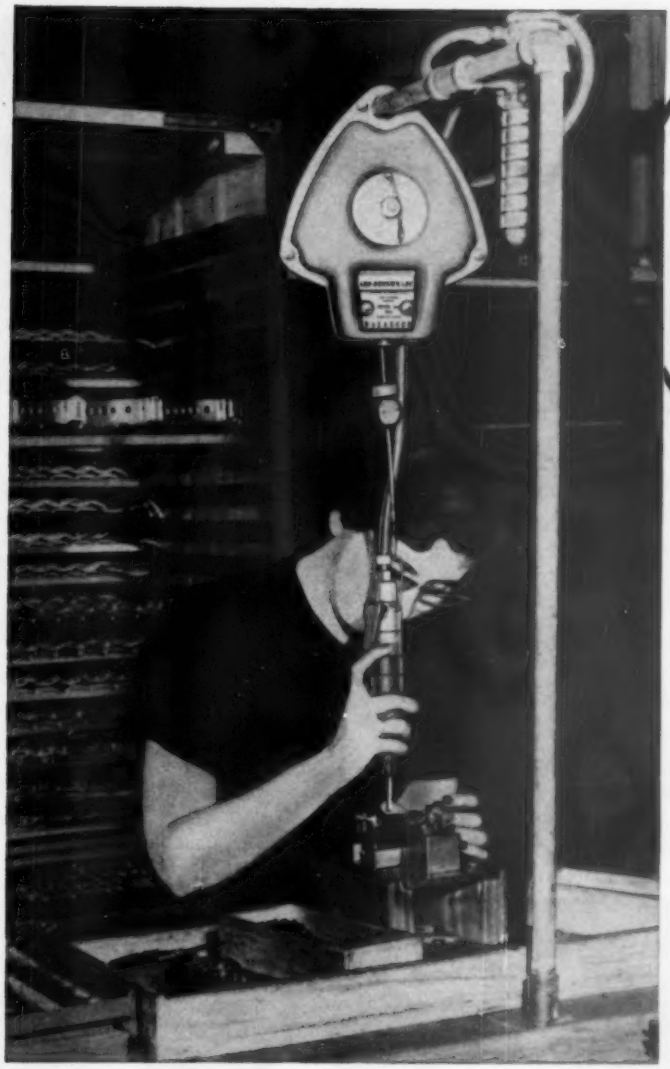

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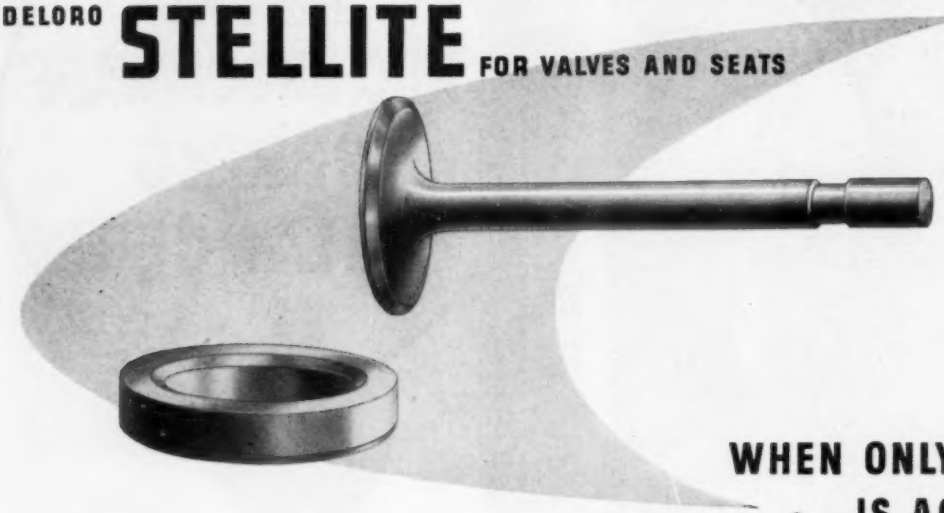

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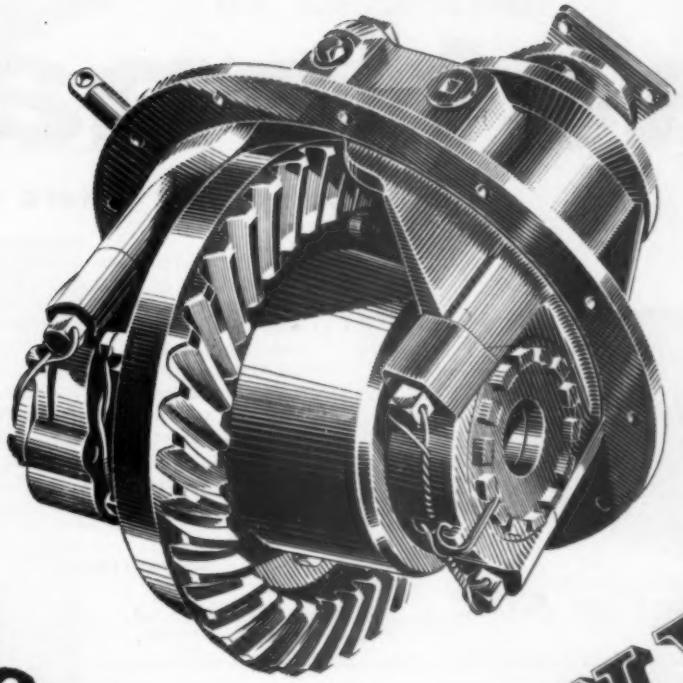

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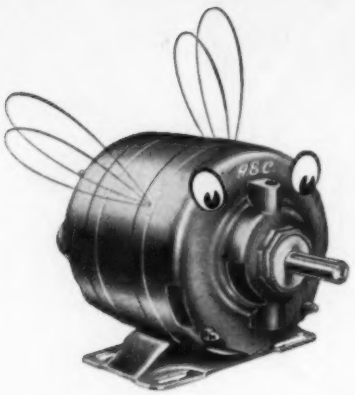

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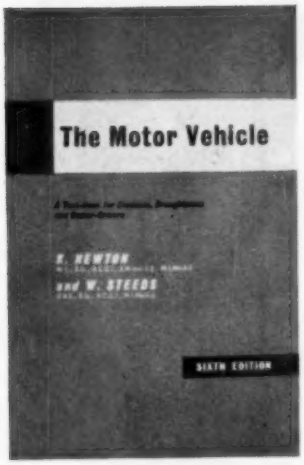

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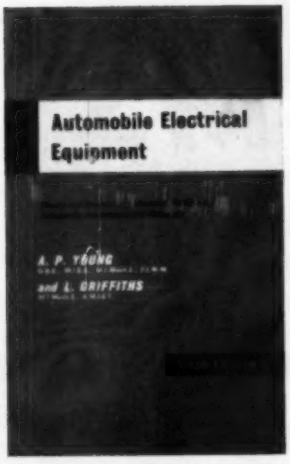

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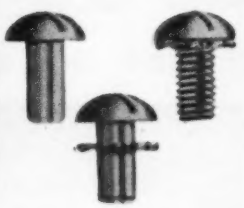

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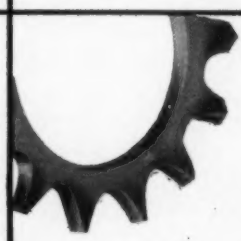

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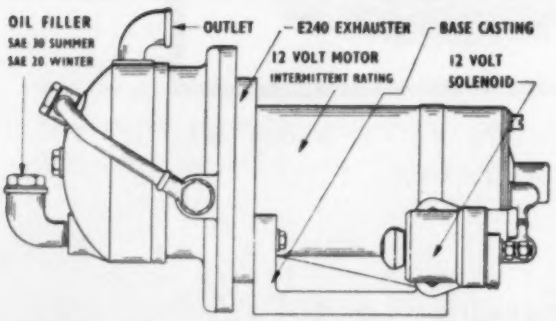

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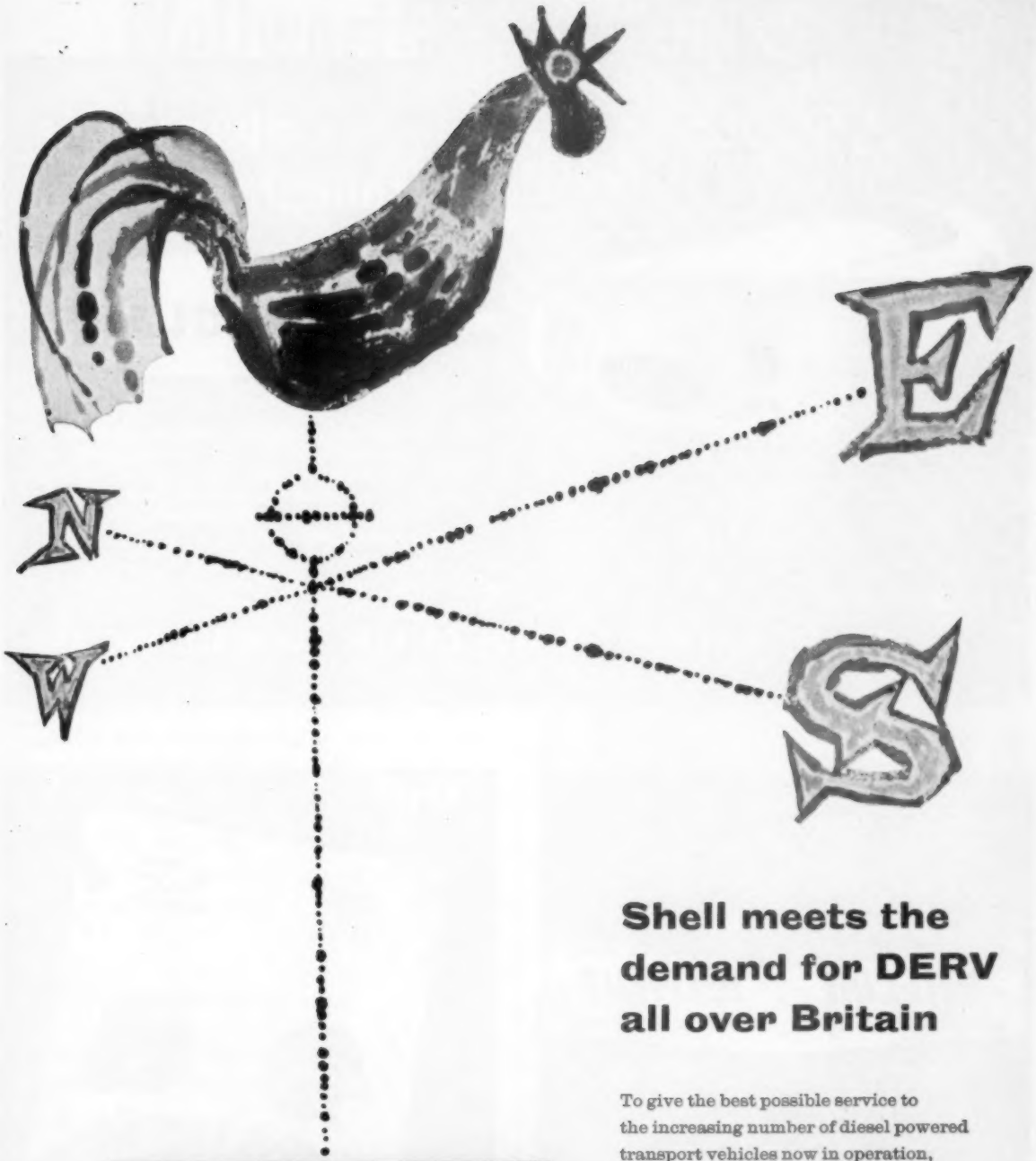

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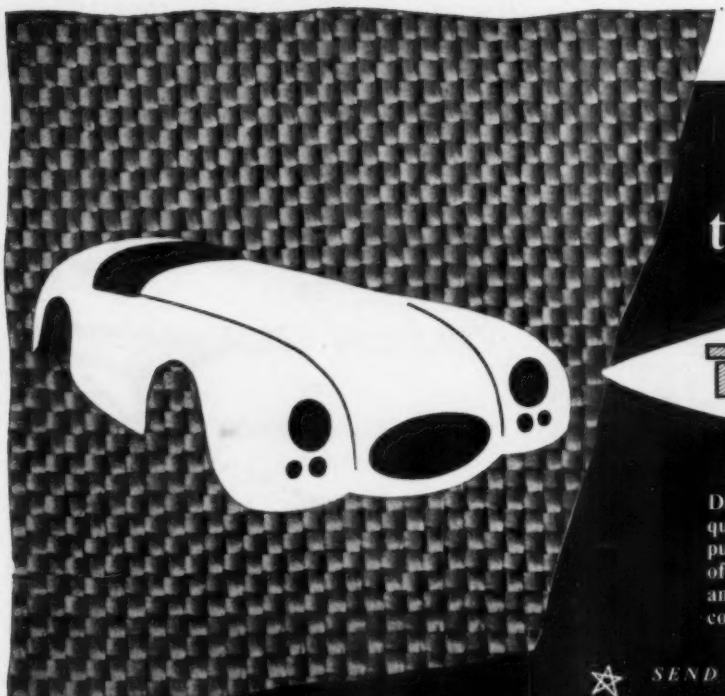

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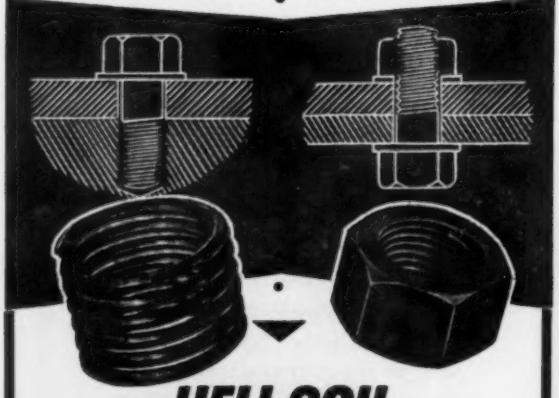

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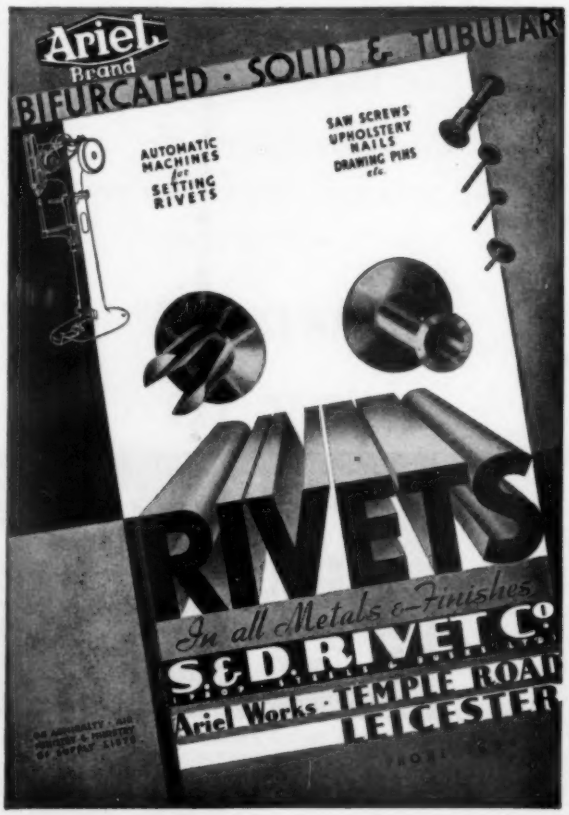

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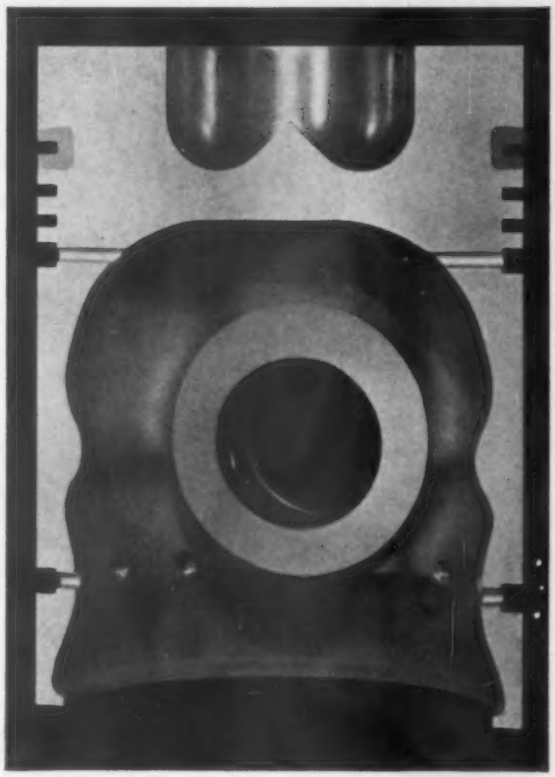

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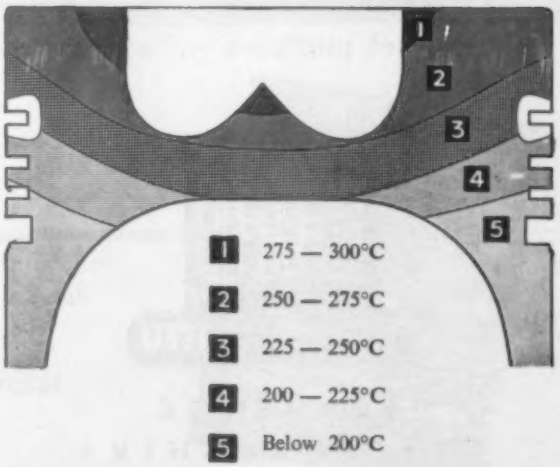

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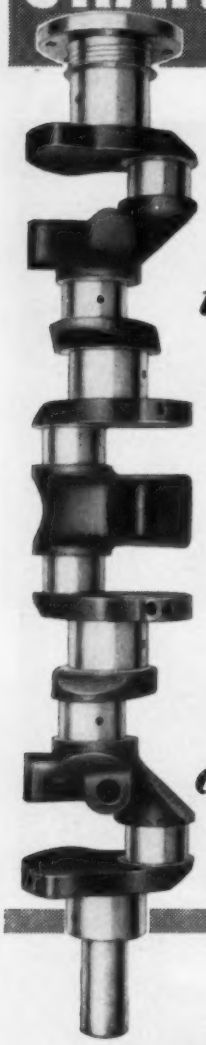

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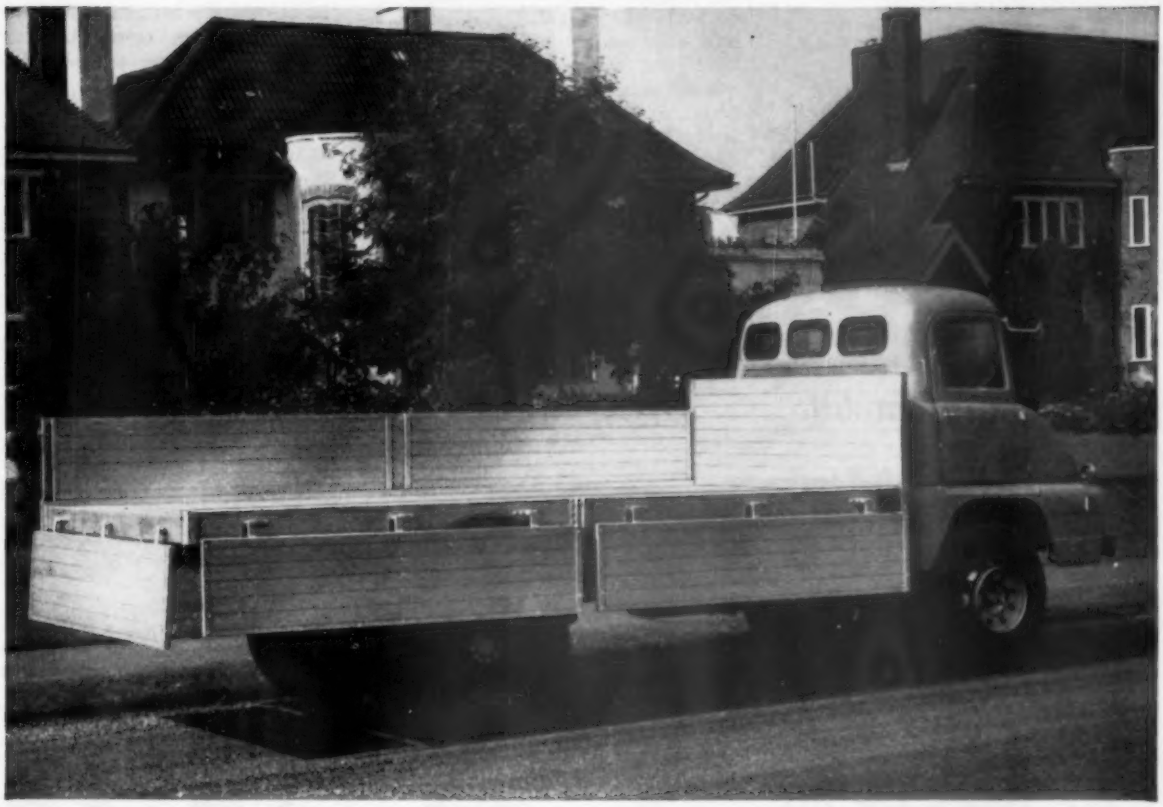

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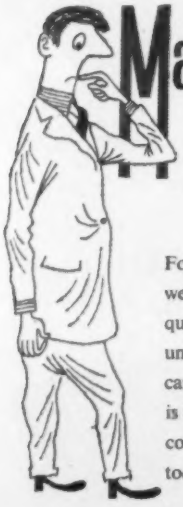

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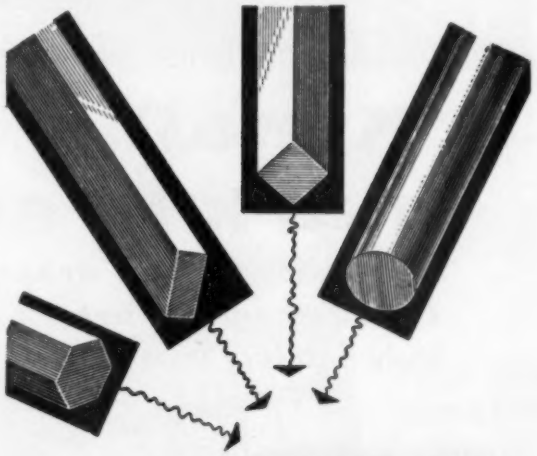

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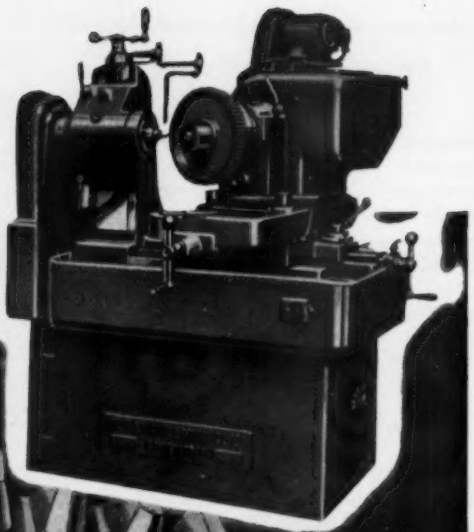

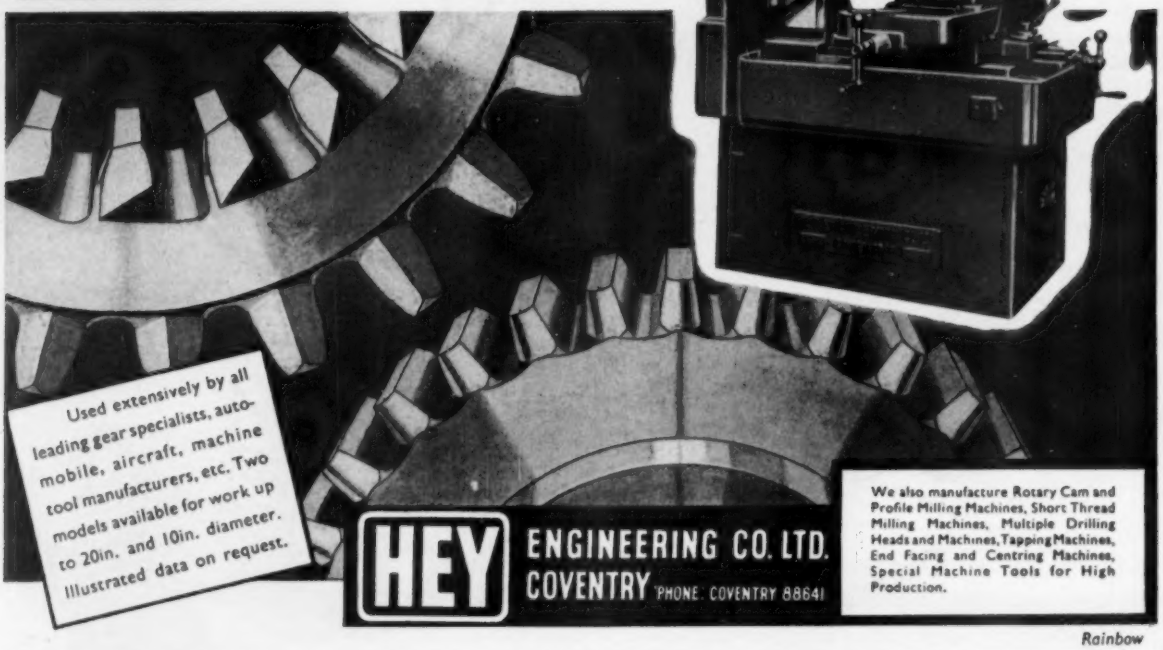

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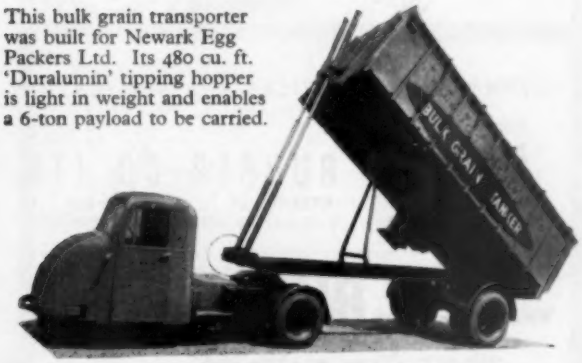

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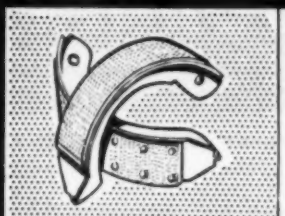

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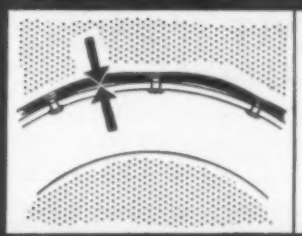

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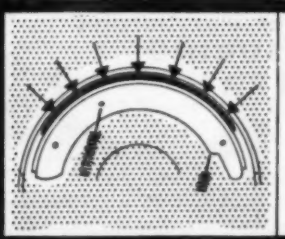

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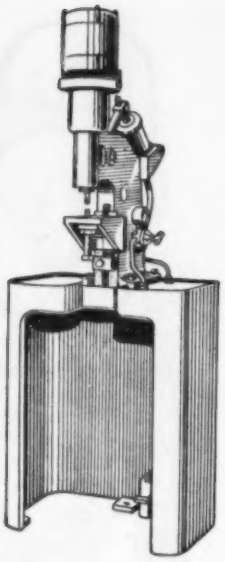

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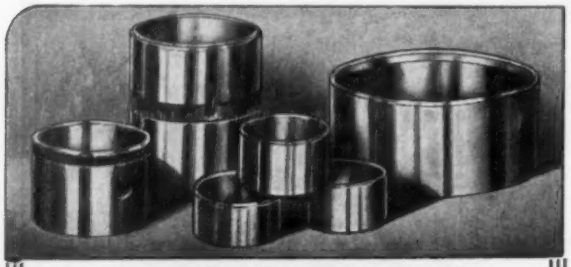

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SIMMS MOTOR & ELECTRONICS CORPORATION LIMITED

SUMMARY OF MR. G. E. LIARDET'S STATEMENT FOR YEAR ENDED 31st DECEMBER, 1957

The Annual General Meeting of Simms Motor and Electronics Corporation Limited was held on July 25th, 1958, at the Company's Registered Office. Mr. G. E. Liardet (Chairman) presided and, in the course of his speech, said:—

"The acquisition of Motor & Electronics Corporation Limited (M.E.C.) in October 1957 implements our policy of diversification and expansion. Our activities in the field of motor vehicle components, general engineering, ventilation and heating, plastics, oil burners and domestic products are now supplemented by many types of electronic components, switch gear and accessories for radio, television, radar and telecommunications, also vacuum ware, transmission couplings, and numerous other products.

"It was considered that the time had arrived when a measure of decentralisation would be beneficial and on the 31st December, 1957, you approved the change of name of Simms Motor Units Limited to Simms Motor & Electronics Corporation Limited and the sale of the assets, other than interests in associated and subsidiary companies, to a new operating company called Simms Motor Units Limited.

"By this means Simms Motor & Electronics Corporation Limited became a Holding Company only, with the object of co-ordinating the activities of the operating companies and the general planning and supervision of Group policy. The Board of Directors remains the same as before, with the addition, as Deputy Chairman, of Mr. M. A. Hassid who is also Managing Director of M.E.C.

"Mr. R. G. Sutton has been appointed Financial Controller in addition to his duties as Secretary of the Corporation. Mr. J. Ayres, previously General Manager, succeeds me as Managing Director of Simms Motor Units Limited, though I retain the Chairmanship of the Board of that Company and I have also been elected Chairman of the Board of M.E.C.

"Mr. Ayres and Mr. Hassid are responsible for the control of the subsidiary companies in the Simms and M.E.C. groups respectively.

"The year has been one of progress and the trading profit before tax is £927,861, compared with £841,711 in 1956.

"The issued capital of the Company has been increased by the capitalisation of £1,440,001 of Reserves.

"The Fixed Assets, other than motor vehicles, have been revalued at the Finchley factory and also in all the companies of the M.E.C. group, such revaluations producing a substantial surplus over the net book values at 31st December, 1957. These adjustments have not affected the Profit and Loss Account for 1957 but there will be a substantial increase in depreciation charges in 1958.

"A further £171,475 has been transferred to General Reserve which now stands at £900,000.

"An interim Ordinary Dividend of 6d. per share was paid in December 1957, and it is hoped to continue this policy in future years. Your Directors recommend a final Ordinary Dividend of 5½d. per share which, with the Interim Dividend, is equivalent to 1s. 10½d. compared with 1s. 9d. per share paid on the capital at 31st December, 1956, since increased by the shares issued on the acquisition of M.E.C. and the subsequent bonus issue.

"The balance of profit carried forward in the Holding Company has increased from £392,788 to £459,946.

"Demand for Group products continued to rise during the year, notably fuel injection equipment for diesel engines, in which sphere I think we can justly claim to be the world's leading manufacturers.

"You will be interested to know that we are shipping a large volume of fuel injection equipment to the U.S.A., thus adding to the dollar earnings of the country.

"All our companies are in good heart and I hope we may be able to present to you a satisfactory result this time next year."

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INDEX TO ADVERTISEMENTS

	PAGE
Adamant Engineering Co. Ltd.	45
Aero Research Ltd.	89
Aluminium Bronze Co. Ltd.	82
Amal Ltd.	100
Andre Rubber Co. Ltd.	54
Angus, George, & Co. Ltd.	32
Archdale, James, & Co. Ltd.	1
Armstrong Patents Ltd.	92
Atlas Copco AB	Cover ii
"Automobile Electrical Equipment"	85
Automotive Products Co. Ltd.	5, 6, 7, 8
Barber & Colman Ltd.	86
Birfield Group	49
Birmetals Ltd.	50
Booth, James, & Co. Ltd.	101
B.R.D. Co. Ltd.	94
British Oxygen Co. Ltd., The	14
British Piston Ring Co. Ltd., The	31
Brook Motors Ltd.	2
Broom & Wade Ltd.	81
Bull, John, Rubber	78
Bury Felt Mfg. Co.	11
Cape Asbestos Co. Ltd., The	22, 23
C.A.V. Ltd.	55
Clancey, G., Ltd.	84
Clayton Dewandre Co. Ltd.	16
Coopers Mechanical Joints Ltd.	107
Copper & Asbestos Washer Co. Ltd.	100
Cossor Instruments Ltd.	56
Cross Mfg. Co. (1938) Ltd.	90
Dartmouth Auto Castings Ltd.	70
Delaney Gallay Ltd.	30
Deloro Stellite Ltd.	82
Desoutter Bros. Ltd.	12
Doncaster, Daniel, & Sons Ltd.	33
Dowty Seals Ltd.	108
Drummond - Asquith (Sales) Ltd.	26, 27
Dunford & Elliott (Sheffield) Ltd.	96
Dunlop Rubber Co. Ltd.	20, 97, Cover iv
Dupree Swift & Co. Ltd.	88
Eaton Axles Ltd.	57
Edwards, F. J., Ltd.	106
E.N.V. Engineering Co. Ltd.	83
Fairman Precision Tools & Products Ltd.	94
Farnborough Engineering Co. Ltd.	69
Feeny & Johnson Ltd.	88
Feltham, Walter H., & Sons Ltd.	106
Ferodo Ltd.	40
Firth-Vickers Stainless Steels Ltd.	51
Flexibox Ltd.	106
Follsain Wycliffe Foundries Ltd.	90
Frank, Charles	104
Fry's Metal Foundries Ltd.	87
Fuller, Horsey, Sons & Cassell	107
General Electric Co. Ltd., The	52, 84, Cover iii
Girling Ltd.	103
Habershon, J. J., & Sons Ltd.	102
Harper, John, & Co. Ltd.	44
Hepworth & Grandage Ltd.	64
Herbert, Alfred, Ltd.	17, 19
Hermetic Rubber Co. Ltd.	102
Hey Engineering Co. Ltd.	98
Hoffmann Manufacturing Co. Ltd., The	73
Holroyd, John, & Co. Ltd.	38
Holset Engineering Co. Ltd.	18
I.C.I. (General Chemicals, Heat Treatment) Ltd.	48
I.C.I. (Metals) Ltd.	95
Ilford Ltd.	46
International Twist Drill Co. Ltd., The	66
Jackson, H., Ltd.	29
Jenks Bros. Ltd.	98
Kirkstall Forge Eng. Ltd.	3
Lapointe Machine Tool Co. Ltd., The	61
Lawrence Bros. Millward Ltd.	104
Lead Development Association	90
Leeds Piston Ring & Engineering Co. Ltd.	100
Ley's Malleable Castings Ltd.	67
Manganese Bronze & Brass Co. Ltd., The	24
Marsden, Samuel, & Son Ltd.	106
M.C.L. & Repetition Ltd.	106
Mek-Elek Engineering Ltd.	106
Metalastik Ltd.	37
Midland Motor Cylinder Co. Ltd., The	Cover i
Moss Gear Co. Ltd.	80
Neill, Jas., & Co. (Sheffield) Ltd.	74
Newall, A. P., & Co. Ltd.	28
Park Gate Iron & Steel Co. Ltd., The	25
Philidas Div. of Whitehouse Industries Ltd.	53
Pollard Bearings Ltd.	47
Ransome & Marles Bearing Co. Ltd.	21
Renold Chains Ltd.	42
S. & D. Rivet Co.	92
Salter, Geo., & Co. Ltd.	10, 63
Sankey Green Wire Weaving Co. Ltd.	78
Schrader's, A., Son	13
Sentinel (Shrewsbury) Ltd.	62
Sheffield Twist Drill & Steel Co. Ltd., The	15, 39
Shell-Mex & B.P. Ltd.	4, 91
Shotton Bros. Ltd.	75
Silentbloc Ltd.	59
Simms Motor Units Ltd.	105
Skefko Ball Bearing Co. Ltd.	72
Small & Parkes Ltd.	102
Smethwick Drop Forgings Ltd.	60
Specialloid Ltd.	86
Steel Co. of Wales Ltd., The	34, 35
Sterling Metals Ltd.	58
Sutcliffe, Speakman & Co. Ltd.	96
Sykes, W. E., Ltd.	43
Terry, Herbert, & Sons Ltd.	79, 94
Thomas, Richard, & Baldwins Ltd.	41, 65
Thompson, John, Motor Pressings Ltd.	88
Tilghman's Ltd.	74
Turner Bros. Asbestos Co. Ltd.	92
Turner Machine Tools Ltd.	104
Udal, J. P., Ltd.	80
Vaughan, A. J., & Co. (Mitre Works) Ltd.	98
Vaughan Associates Ltd.	9
Ward, Thomas W., Ltd.	36
Wellworthy Piston Rings Ltd.	93
Weston, Charles, & Co. Ltd.	99
Wild-Barfield Electric Furnaces Ltd.	77
Wiley, James, & Sons Ltd.	76
Wilmot Breeden	68

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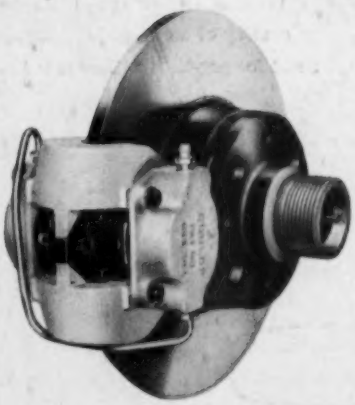

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